GEORGE F. NORDENHOLT, *Editor*

Blind Hate and Unreasoning Hysteria

IT HAS OFTEN BEEN SAID that a nation must be made to hate its enemies in order to overcome them. That is the basic reason for most war propaganda. But such propaganda is a double-edged sword.

Before and during World War I, the American public was thoroughly soaked with propaganda. To their discredit, they swallowed much of it "hook, line and sinker" with the result that many foolish things were done that contributed nothing to the cause and even reacted unfavorably. The teaching of German was barred from practically all schools, an act so silly that only a mind warped by blind hatred could justify it. To know your enemy's language and customs is a powerful weapon which has been used with great success in every war.

To hate so completely that one is blind to the points of superiority of an opponent is the surest road to disaster. Many prize fighters win by taunting their opponent into a blind fury. One way to victory is to study closely everything that the opponent possesses and quickly adopt everything good that he has. Hate his unworthy principles, hate his villainous acts, but don't hate blindly.

Likewise hysteria, born of fear and hate, spells the doom of any individual or nation that becomes a victim to it. Unreasoning hysteria born of fear will stampede any herd, be it cattle or humans. Unfortunately, the forthcoming political campaign may well breed groundless cause for hysteria. Probably much capital will be made of the unpreparedness of the United States and of the long time that will be required to put the country in a strong defensive position.

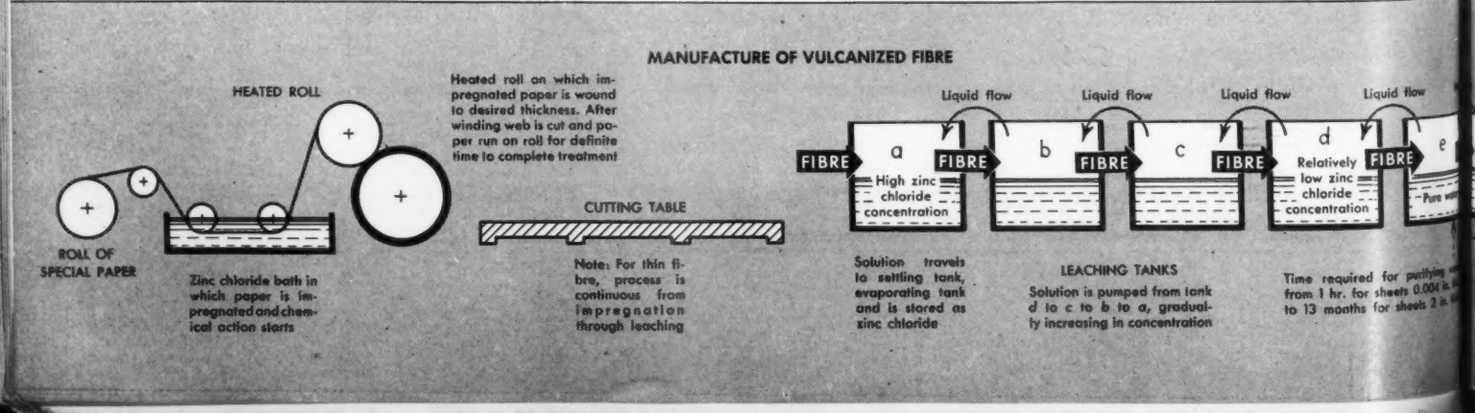
What is past cannot be changed, but this is no cause for hysteria. The preparedness program is not only in excellent hands but it is being executed in a most thorough and expeditious manner. The active heads of it are two great and capable industrial leaders working in cooperation with the Army and Navy. They have frankly copied the German principle of thoroughness and are tieing the needs of the Army and Navy to the productivity of the greatest industrial system the world has ever known.

Stettinius and Knudsen are not men who can be blinded by fear or stampeded by hysteria. They are planning thoroughly and are rapidly putting the wheels of industry into swift motion. The errors of 1917 are being avoided, there is no running around in circles, every move is counting, and they are gearing to maximum efficiency the world's most powerful war machine—American industry dedicated to the defense of its nation.

Blind hate and unreasoning hysteria have no place in a national defense program. It requires calm deliberation and determined execution to accomplish results. And that is the way the National Defense Advisory Commission is operating. Every patriotic American citizen should support it with comparable calmness and determination. Heed not false prophets.

VULCANIZED FIBRE

VULCANIZED fibre, sometimes called hard vulcanized fibre or chemically hardened fibre, is obtained by treating cotton rag paper with zinc chloride, which causes the cotton fibres of the paper to swell and partially gelatinize. The gelatinized fibres within the paper adhere firmly to each other and superimposed plies of paper laminate into a solid mass of converted cellulose, which is leached in water until the zinc chloride is removed. It is then dried, pressed and calendered. The main factors determining the suitability of the paper for fibre making are the inherent strength of the cotton strands; length of the strands; how well and uniformly the strands are felted; absorption, which determines how well the paper will take up chemicals; hydration; and, most important of all, the reactivity of the paper. The last two determine how well the paper will respond to the chemical treatment. For these reasons, producers of vulcanized fibre usually manufacture, or control the manufac-


MANUFACTURE OF VULCANIZED FIBRE
HEATED ROLL
ROLL OF SPECIAL PAPER
Zinc chloride bath in which paper is impregnated and chemical action starts
Heated roll on which impregnated paper is wound to desired thickness. After winding web is cut and paper run on roll for definite time to complete treatment
CUTTING TABLE
Note: For thin fibre, process is continuous from impregnation through leaching
Liquid flow
Liquid flow
Liquid flow
Liquid flow
FIBRE
a
b
c
d
e
High zinc chloride concentration
Relatively low zinc chloride concentration
Solution travels to settling tank, evaporating tank and is stored as zinc chloride
LEACHING TANKS
Solution is pumped from tank d to c to b to a, gradually increasing in concentration
Time required for purifying from 1 hr. for sheets 0.004 in. to 13 months for sheets 2 in.

ture of, the paper stock so that these qualities are maintained.

The vulcanized fibre making process, illustrated below, is the method commonly used to make thick fibre. Electrical insulation, trunk fibre, and other thin fibres are made by a continuous process. As many rolls of paper as are required to make the thickness desired are mounted on a stand. The webs of paper are passed simultaneously through the zinc chloride bath, over the cylinders, and then onto a long carrier in a continuous web to the purifying tanks. For leaching, the fibre in web form is passed from tank to tank automatically.

Time required for purifying the fibre sheets varies from about one hour for fibre 0.004 in. thick to thirteen months for fibre 2 in. thick. Time required for drying, like the time required for purifying, increases with the thickness. The purified sheets are hung in a heated room, the process being similar to the drying of wood in a kiln. Continuous fibre is dried on a dryer similar to a paper dryer. Six per cent is considered normal moisture content of fibre. If more than this amount of moisture is driven off, brittle fibre will result. The sheets which invariably warp considerably in the drying operation, are straightened between heated platens of hydraulic presses. Continuous fibre is held taut against the dryer cans and is produced in straight smooth sheets which do not require pressing. Calendering produces the smooth surface and increases density to a limited extent. However, density is primarily a function of the chemical action.

Tubes are produced by passing the paper through zinc chloride and immediately winding it on mandrels. Semi-automatic machines are used for this operation. Size of mandrel determines inside diameter of tube, and number of plies determines wall thickness. Mandrels are removed while the tubes are being purified and are again inserted before the tubes go into the "dry house." After drying the tubes, with mandrels inserted, are rolled to approximate size between grooved rolls similar to those of a rod mill. Final sizing of outside diameter is done on centerless grinders. Fibre rods are made by sawing sheets into rectangular rods and grinding them round on centerless grinders. Large rods are first turned on a dowel machine and then ground to size.

In 1846, two French chemists discovered that filter paper, dipped in 66 deg. Be. sulphuric acid, washed free of acid and dried, materially changed its character. The soft porous filter paper had become a hard, dense substance. For some years this remained merely a scientific fact. In 1859, an Englishman, Thomas Taylor, discovered that a 70 deg. Be. zinc chloride solution produced the same general effect on filter paper as sulphuric acid. Taylor patented the zinc chloride method in England and tried to find some commercial use for his product. Either Taylor, or some of his contemporaries, discovered that sheets of paper, treated with sulphuric acid or zinc chloride and laminated under light pressure, would stick firmly together and, when leached free of the chemical and dried, would form a hard, almost homogeneous substance.

The term "vulcanized" had some fifteen years earlier come into use in connection with rubber, to denote rubber hardened by chemical means. Taylor hardened cellulose fibres by chemical means and called his product "vulcanized" fibre. In 1873 Taylor started the fibre industry in this country.

Fibre may be formed when it is moistened, the degree of moistening depending on the complexity of the shape being formed. The fibre becomes pliable as it absorbs moisture and when dried again becomes a hard, dense material. It is usually formed in either a punch press or hydraulic press. The former is used for relatively simple jobs that require little or no moistening or rely on the inherent moisture content of the material, and where the job can be accomplished in less than a second.

Simple bends can be made in an angle brake. The fibre is moistened, bent to shape, and then held in suitable forms to dry and harden. Forming is usually done in a punch press, particularly for cupping and crimping. V-shapes are also formed in a punch press. Heated dies aid flow of the material and prevent fracture. Washers are swaged in a punch press but length of the raised section is limited to approximately one-half the thickness of the stock. For cupping operations, slight humidification of the fibre sheets is recommended. Grain should run parallel to bend to prevent breakage.

For deep drawing such as miners' helmets, it is usual practice to soak the material and form it in a hydraulic press, after which it is dried to shape in heated dies. The material can be embossed and grained in hydraulic presses, or by use of a special calendering roll.

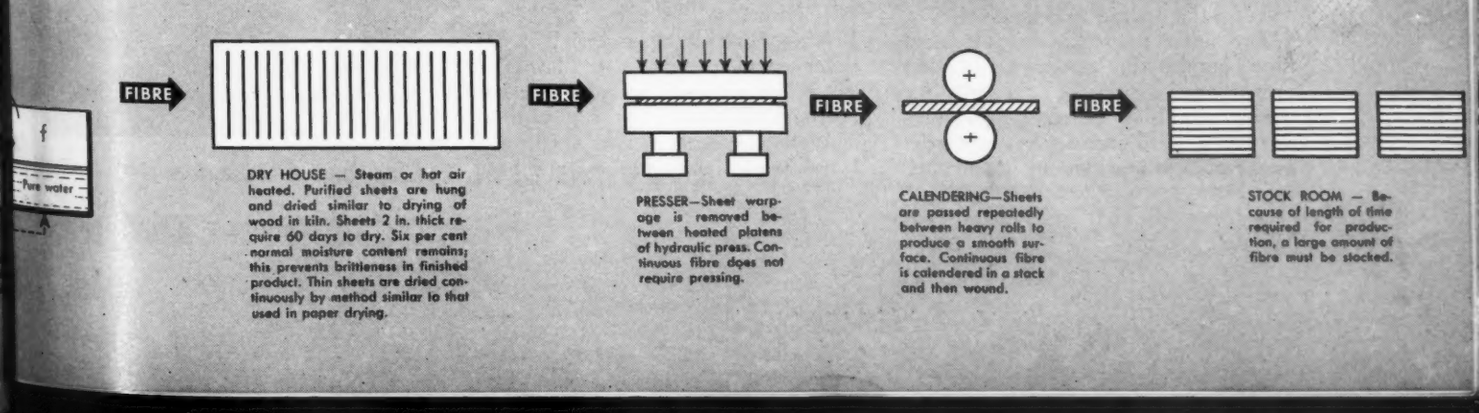
Fibre is difficult to roll. The shapes or sections illustrated are formed in a hydraulic press to the desired shapes and are then cut into short pieces. Special shapes can be made from round fibre tubing, placed on a mandrel of the desired shape and passed through heated rolls. For irregular shapes, the fibre is moistened to aid flow.

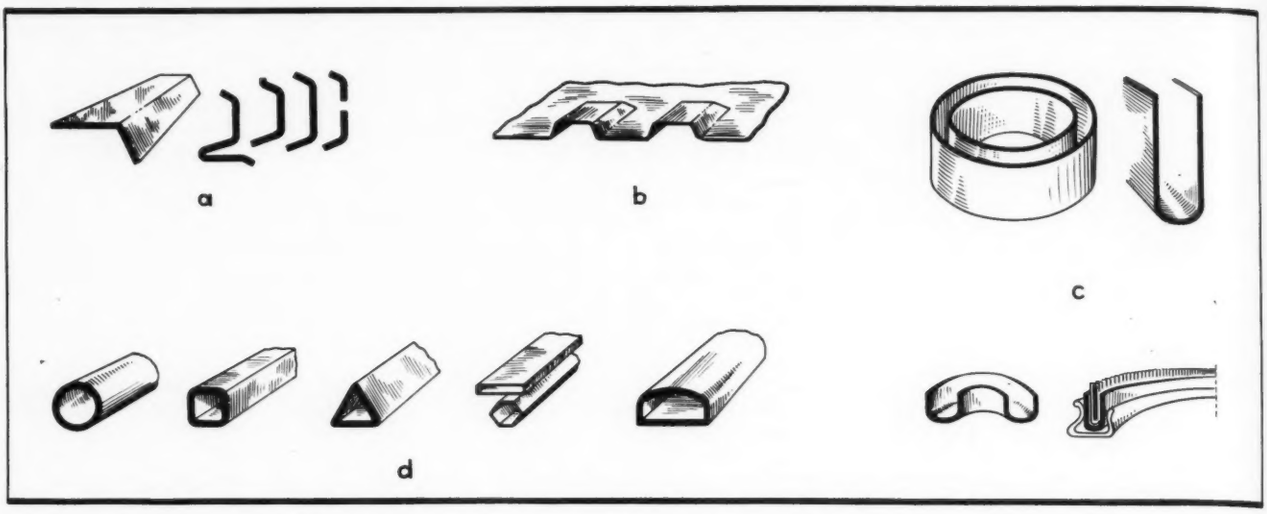
Tubing can be flared by spinning in a screw machine, utilizing a stationary tool. Frictional heat aids the flow in this "belling" operation. Tubing can be swaged or elongated in the same manner. Screw machines are also used to spin the tubing inwardly, this operation also utilizing frictional heat to aid the flow of the material.

In making shrink fits, the fibre tube is moistened and then worked until its circumference is slightly increased. It is then slipped over the shaft or pulley or disk slightly larger in diameter than the original diameter of the tubing. When dry it shrinks into position and will not loosen unless moistened.

Because of its good electrical properties, particularly its resistance to arcing and tracking, vulcanized fibre is used in the electrical field where a material is required that is tough enough to withstand shocks, has high strength and good machining qualities. Typical uses are for socket and toggle switches, air circuit breakers, fuses, grommets, coil forms, shields, among many others. Since fibre contains no volatile matter, it does not give off any gas that will carbonize when subjected to an arc.

Fibre combines good electrical properties with high mechanical strength. However, because the material is hygroscopic, in applications involving high humidity conditions it will ab-


FIBRE
FIBRE
FIBRE
FIBRE
DRY HOUSE — Steam or hot air heated. Purified sheets are hung and dried similar to drying of wood in kiln. Sheets 2 in. thick require 60 days to dry. Six per cent normal moisture content remains; this prevents brittleness in finished product. Thin sheets are dried continuously by method similar to that used in paper drying.
PRESSER—Sheet warpage is removed between heated platens of hydraulic press. Continuous fibre does not require pressing.
CALENDERING—Sheets are passed repeatedly between heavy rolls to produce a smooth surface. Continuous fibre is calendered in a stack and then wound.
STOCK ROOM — Because of length of time required for production, a large amount of fibre must be stocked.



Typical shapes formed from vulcanized fibre sheets and rods, utilizing brakes, punch presses and hydraulic presses

sorb moisture. Where high humidity conditions prevail, coating the fibre with paraffin or varnish will render the fibre moisture resistant. Fibre will absorb moisture rapidly when actually immersed in water but absorption caused by change in humidity is relatively slow; hence temporary exposure to high humidity will not have any appreciable influence.

Combination tubing, consisting of a fibre tube covered with a laminated plastic tube, is used extensively in high tension work as casings for fuses and lightning arresters which operate outdoors in all weather conditions. The purpose of the internal fibre tube is to give the cartridge a high arc resistance so that when a fuse blows or when lightning surges jump the electrodes, there will be no carbonization or "tracking" to allow current flow. In addition the fibre liner provides the high mechanical and bursting strength necessary because of the enormous pressures generated in the tube when arcing occurs. The laminated plastic outer tube provides resistance to weathering.

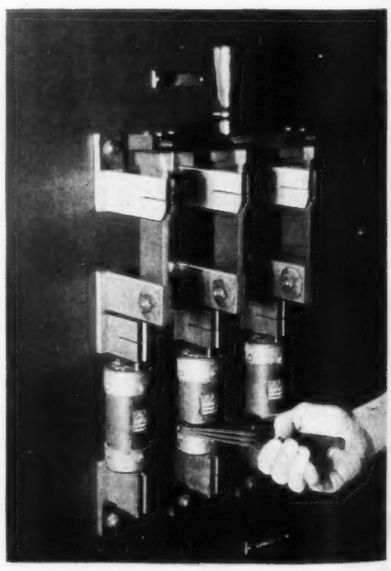
The fibre tubes were originally telescoped inside of phenolic tubes, but there was poor bond between the fibre and phenolic tubes and in many cases the fibre liners fell out. After considerable work a method was developed whereby a phenolic covering could be rolled on the fibre tube thus making it an integral part of the fibre liner. If the wall of the fibre portion is large, one or more fibre tubes are telescoped to make the desired wall thickness.

Two other properties of vulcanized fibre besides its neutral-gas-forming property make it particularly suited for use in expulsion tubes. Fibre under steadily applied stresses has strengths comparable to other organic insulating materials but its impact strength or shock resistance is from three to seven times greater. Hence, the fibre liner in the cimbination tubes can resist the impact stresses set up by the spontaneous generation of the gas. When an arc plays on fibre it volatilizes completely without any carbon deposit. As many as ten discharges of 100,000 amperes each have been sent through a combination expulsion tube without leaving traces of carbon on the exposed surfaces. The phenolic-covered tubes have excellent weathering characteristics and are free from warpage. Examination of tubes from both service and accelerated life tests have indicated that the phenolic portion retains its dielectric and mechanical properties when subject to normal weather conditions. There is a slight discoloration of the phenolic wrapping after the original finish disappears but this condition is neither harmful to operating characteristics nor injurious to the durability of the composite tube.

Another important application for vulcanized fibre is in the insulation of rail-block joints. The current that actuates automatic railway signals is transmitted through the rails and it is therefore necessary to insulate one block from another. Vulcanized fibre is the only material thus far developed that has proved to be satisfactory for this particular application. Since it is hard and tough, it withstands the flexing of the joint and the pounding on the rails of heavy locomotives and cars. It is formed to the contour of the rail. Being a hard, stable material, it does not flow under compression. Flow might cause loosening of the bolts that hold the joint together.

Another extensive use of fibre is found in grommets, washers and bushings that protect electrical cord from abrasion. The fibre is electric- and heat-resistant, is not brittle and improves in toughness and hardness with age. It can be formed easily by swedging in a punch press. Fibre washers are extensively used in the plumbing industry as the fibre swells in presence of water to form a tight seal.

Coil forms are assembled of two disks punched from sheet and attached to a fibre tube by spinning the two ends outwardly. To prevent inward movement of the disks a small shoulder is turned on the tube. This is satisfactory when wire is to be wound on the assembled coil; in some instances wire is first coiled on the tube and the disks then spun into place. Another type of coil form consists of a disk punched from sheet fibre and having a series of



Fibre fuse tubes and a fibre puller

formed projecting lugs around which wire is wound. This is inexpensive and space-saving, and is useful for antenna transformers in radio receivers where wood could not offer the high electrical insulating properties required.

Fibre can be glued or cemented to flat surfaces. In the textile industry use of this, in connection with high impact strength and resilience properties, is exemplified in fibre armored shuttles. The shuttles have glass-smooth, polished, non splintering surface. Bobbin heads made of fibre do not chip, splinter, or crack.

The resilience of fibre makes it useful for quiet-running gears and cams, since the slight yield of the material under impact tends to prevent wear or grinding and reduces shocks and strains on the equipment on which it is mounted. However, possible dimensional changes in fibre must be considered. Fibre disks can be built up to any thickness and riveted or bolted together with metal shrouds, and then lathe-turned or hobbed to shape. Pulleys in some cases are machined from solid sheet stock.

Since fibre is tough and hard, the cutting edges of tools must be kept in good condition. The material is slightly elastic and tends to impinge against the back of the tool and generate heat. For quantity production high-speed steel or tungsten-carbide tools are recommended, sharpened the same as for cutting brass. Slightly negative rake and large clearance are required for turning and boring operations. Allow 400 ft. per min. peripheral speed for high-speed steel tools and 700 ft. per min. for carbide tools, taking as coarse a cut as possible and feeding as fast as is consistent with finish desired.

For tapping, high-speed steel taps are recommended. A slight amount of oil on tap aids chip removal. Speed is 100 ft. per min. When tapping parallel with laminations, material should be clamped to equalize stress and prevent possible splitting. For fine threading, chasing on engine lathes is preferred. Self-opening dies are better for quantity production. Threading speed with high-speed steel tools is 70 r.p.m., the same as for brass.

Punching should be done at right angles to the grain of the material. Two general methods are favored:

Properties of Vulcanized Fibre

(adapted from N.E.M.A. standards)

	Grade		
	Electrical Insulation	Mechanical (Commercial)	Bone Fiber
General Characteristics	For electrical insulation. Has high dielectric strength, good mechanical strength, good flexural strength. Thin stock is known as "fish paper"	For general mechanical applications	Harder grade of "mechanical" fibre
Color	Gray or bluish gray	Red, black or gray	Gray
Forms Available	Sheets	Sheets, Rods, Tubes	Sheets, Tubes, Rods up to $\frac{5}{32}$ in in diam.
Tensile strength lb. per sq. in. (min.)		Thickness to $\frac{1}{8}$ in. 6,000 crosswise 3,000 lengthwise $\frac{1}{8}$—$\frac{1}{2}$ in. 5,500 crosswise 7,500 lengthwise Over $\frac{1}{2}$ in. 5,000 crosswise 7,000 lengthwise	Thickness to $\frac{1}{8}$ in. 6,500 crosswise 3,500 lengthwise $\frac{1}{8}$—$\frac{1}{2}$ in. 6,000 crosswise 8,000 lengthwise
Compressive strength lb. per sq. in. (min.)		All thicknesses 20,000	All thicknesses 30,000
Flexural strength lb. per sq. in. (min.)		$\frac{1}{2}$ in. thick and over Crosswise 11,000 Lengthwise 13,000	
Dielectric strength volts per mil. (min.)	Thickness in in. 0.004—0.005 200 0.005—0.015 300 0.015—0.040 250 Over 0.040—$\frac{1}{8}$ 175	Thickness in in. Up to $\frac{1}{16}$ incl. 175 $\frac{1}{16}$—$\frac{1}{8}$ 150 $\frac{1}{8}$—$\frac{3}{8}$ 100 $\frac{3}{8}$—$\frac{1}{2}$ 50 Over $\frac{1}{2}$ 25,000	
Water absorption per cent change in wt. (max.)		Thickness in in. 2 hr. 24 hr. $\frac{1}{32}$—$\frac{1}{8}$ 55 65 $\frac{1}{8}$—$\frac{3}{8}$ 25 60 $\frac{3}{8}$—1 15 35 Over 1 8 20	Thickness in in. 2 hr. 24 hr. $\frac{1}{32}$—$\frac{1}{8}$ 50 60 $\frac{1}{8}$—$\frac{3}{8}$ 20 50 $\frac{3}{8}$—1 10 25 Over 1 5 15
Minimum density (Density = spec. gravity when spec. gravity is based on water at 4 deg. C.)	Thickness in in. Under 0.010 0.90 0.010—$\frac{3}{32}$— 1.15 3.32—$\frac{5}{8}$ 1.20 $\frac{5}{8}$—1 1.10 1—1¼ 1.05 1¼ 1.01	Same as electrical grade	Thickness $\frac{1}{32}$—$\frac{1}{2}$ in. 1.30

punching similar to metal punching—using progressive or compound dies, and shaving—using hollow dies of hardened tool steel. Since fibre possesses a fair amount of resilience, punches should be made slightly oversize and dies should be slightly undersize to allow for the flow of the fibre in the punching operation. Allowance depends on the stock thickness, size of the hole, and density of the material. Recommendations should be obtained from the manufacturer. In difficult punching operations it is advantageous to heat the fibre. In this case, allowance might also have to be made for shrinkage due to cooling of fibre after punching.

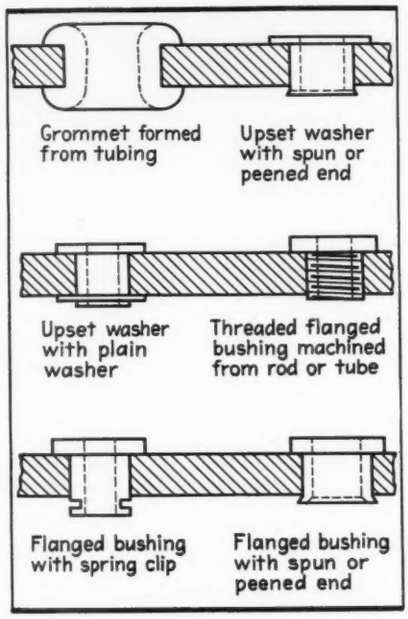
Shaving produces a smooth edge. Brass or soft steel plate on ram of punch forces material through the hardened steel hollow die. Die should have 45 deg. bevel on cutting edge, and gives best results if a trifle dull. Invariably fibre can be shaved cold and up to $\frac{1}{8}$ in. thick can be punched out of the strip. Above this thickness it is best to punch or saw the blanks and place them on the die one by one. Under difficult punching operations, such as on 1 in. thick or heavier fibre, it is advantageous to heat the fibre. An application of oil will also be of assistance. Again, account must be taken of the resilience of the material, the hole will be slightly smaller than the punch and the shaved disk will be slightly larger than the die.

Fibre should be drilled at the highest speed that will not burn the tool. High-speed steel or special drills with greater spiral, narrow web, and wide flutes are recommended, ground with a liberal clearance. Fibre should be drilled perpendicular to the grain when possible. Ordinarily the drilled hole is a few thousandths smaller than the drill; this may be overcome by grinding the drill slightly off center.

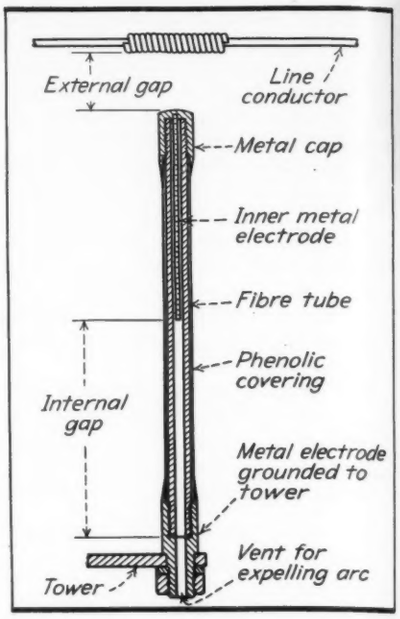
Rough or band sawing. For rough cuts band saws $\frac{1}{4}$ in. to 2 in. wide are used according to the thickness of the stock and the nature of the work. Saws should be run at approximately 4,000 lineal ft. per min. The teeth should be ground straight across because the saw will not cut straight if the cutting edge is not square with the band. When smooth edges or accurate dimensions are required on tubing or sheets, use 14 in. hollow ground circular saws with 120 teeth for stock up to $\frac{1}{4}$ in. thick, with 80 teeth for stock over $\frac{1}{4}$ in. thick. Saws should be run at approximately 3,000 r.p.m. Saws are usually ordered hollow ground 10-13-10 gage, tempered bone hard. Saws should be kept sharp and have little front rake with a liberal amount of clearance, bringing each tooth to a sharp point.

Fibre should always be bent parallel to the grain (long way of the sheet), because it is difficult to bend it across the grain without breaking. It is general practice to soften the material by immersing in hot or cold water and then drying it in heated forms under sufficient pressure to keep the shape desired. If the material can be steamed instead of immersed, it will require less setting time.

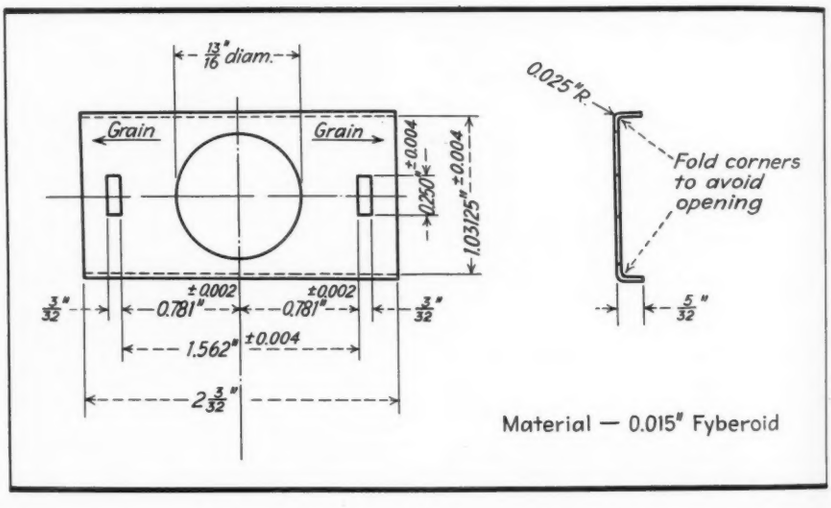
Shearing fibre is similar to shearing brass or soft metal. However, the capacity of the shear for fibre will be three times that for soft steel. When a good edge is desired, the limiting thickness of fibre is $\frac{1}{8}$ in. Larger thicknesses can be sheared if finish of the edge is not important, or if subsequent machining is possible.


Grommet formed from tubing
Upset washer with spun or peened end
Upset washer with plain washer
Threaded flanged bushing machined from rod or tube
Flanged bushing with spring clip
Flanged bushing with spun or peened end

Methods of insulating holes and protecting insulation with fibre grommets



Combination laminated phenolic and fibre tube used as lightning arrester



Fan bearing bracket insulation—working drawing

THE EDITORS acknowledge with thanks the cooperation of Mr. H. T. Lundquist of the *National Vulcanized Fibre Company*; Mr. H. M. Romig of the *Wilmington Fibre Specialty Company*; Mr. J. T. McCloskey of the *Taylor Fibre Company*; Mr. H. C. Steadman of *Spaulding Fibre Company*; Mr. Nelson W. Sieber of *Continental-Diamond Fibre Company*; and Mr. H. T. Davis of *Brandywine Fibre Products Company*. All of these furnished valuable data and helpful criticism. Photographs were supplied by the *National Vulcanized Fibre Company*.

Modern Designs

Reduced Height, Quieter Operation through Re-design

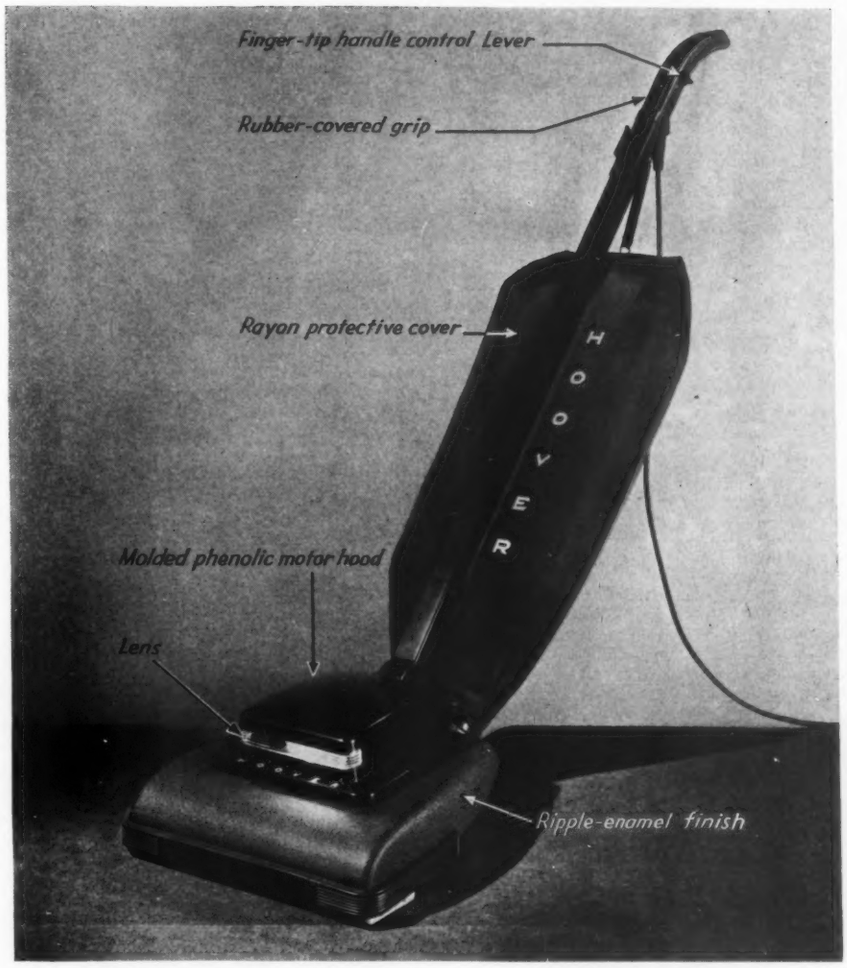
Behind the design refinements—

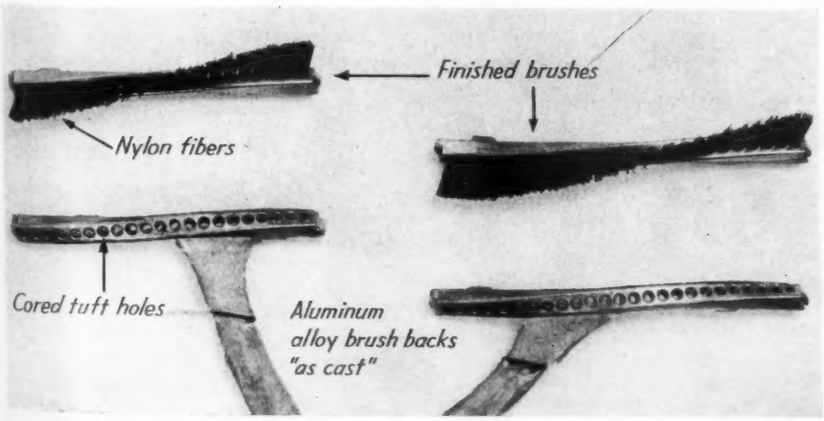
"In the model 60 Hoover cleaner we have incorporated the first major results of ten years' research in the reduction of noise developed by cleaners. This research program involved three years' activity at the University of Michigan to give us a start with the building and equipping of our own sound laboratory, the training of operators, and the analysis of noises. An intense study of means to reduce cleaner noises followed; the results of this study have been incorporated in the new model Hoover.

"Improved balancing equipment has been installed and high frequency tests for electrical units have been devised by the engineering department to improve quality. Similar equipment for noise evaluation is in course of development which when completed will become part of the regular inspection apparatus on the production line.

"Model 60 introduces the use of Nylon fibers in the brushes of the carpet contacting element. A cooperative development program with du Pont was inaugurated as soon as it became apparent that Nylon would be suitable for brush fibers. Actual service tests on these new synthetic brushes indicated that life would be four times as long as that obtained with the usual horse hair bristles."

D. G. SMELLIE, *Chief Engineer*

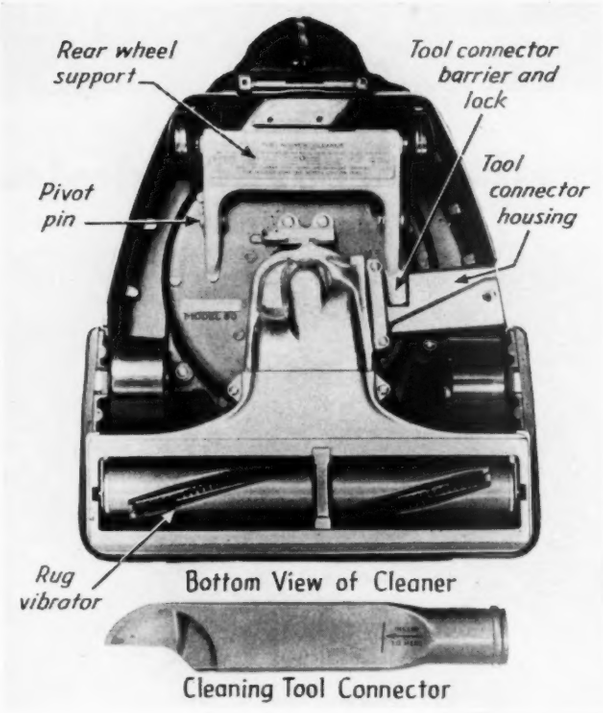




Brown ripple enamel finish, with good abrasion resistance, is applied to the main casting. Styled by Henry Dreyfuss, the color scheme is brown with gold trim. Through redesign of motor, housing and fan system, overall height was reduced to 6⅝ in. as compared with 7⅞ in. for previous model.

Operating noises were reduced through use of helical brushes. Aluminum alloy brush backs are die-cast to the finished shape, despite the fact that there are 25 cored holes in the long brush. Use of Nylon allowed close specification of brush stiffness.

MODERN DESIGNS — Motor Redesign Reduces Cleaner Height

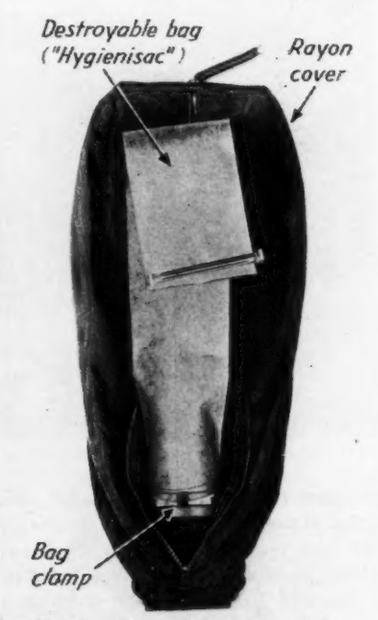


Bottom View of Cleaner

Cleaning Tool Connector

Mechanism which allows easy insertion of the cleaning tool connector for above-the-floor cleaning is shown at left in the bottom view. To insert this connector, the rear of the cleaner is depressed, causing the rear wheel support to pivot on the main casting. This removes the tool connector barrier, allowing insertion of the connector through the housing. Release of pressure allows the leg of rear wheel support to rest on the tool connector, locking it in place and at the same time keeping the nozzle of the cleaner raised from the carpet. Pulley cover is die-cast. Manually operated mechanism for raising and lowering nozzle was eliminated by designing so that nozzle lips assume correct height.

Seventeen parts of high impact phenolic molding materials are used in the cleaner and accessory fittings. A special graphite-filled phenolic is used for the wheels to prevent squeaking after a period of use, as lubrication of the shaft alone previously did not accomplish this purpose. Exterior parts are brown for decorative reasons, the interior parts are molded in jet black.

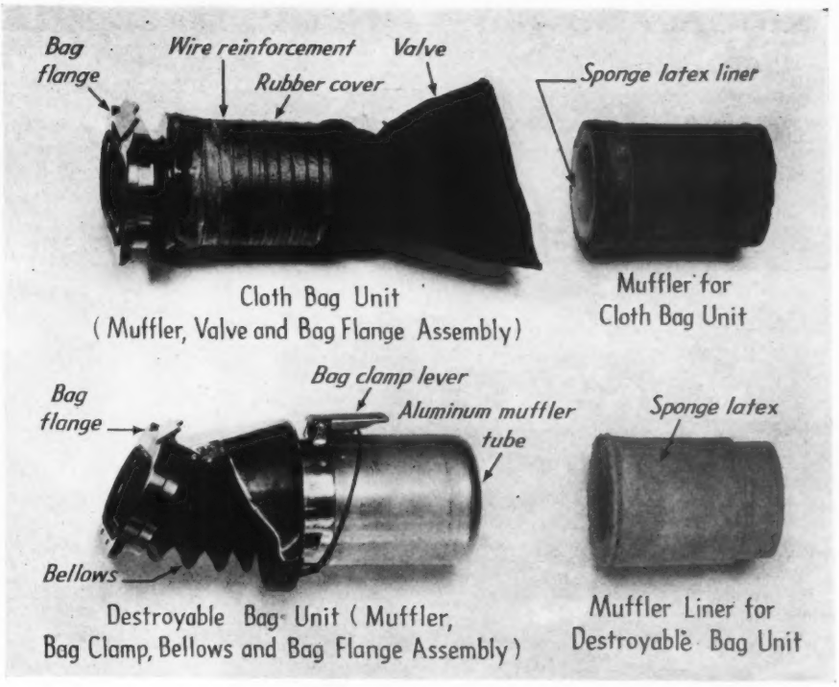


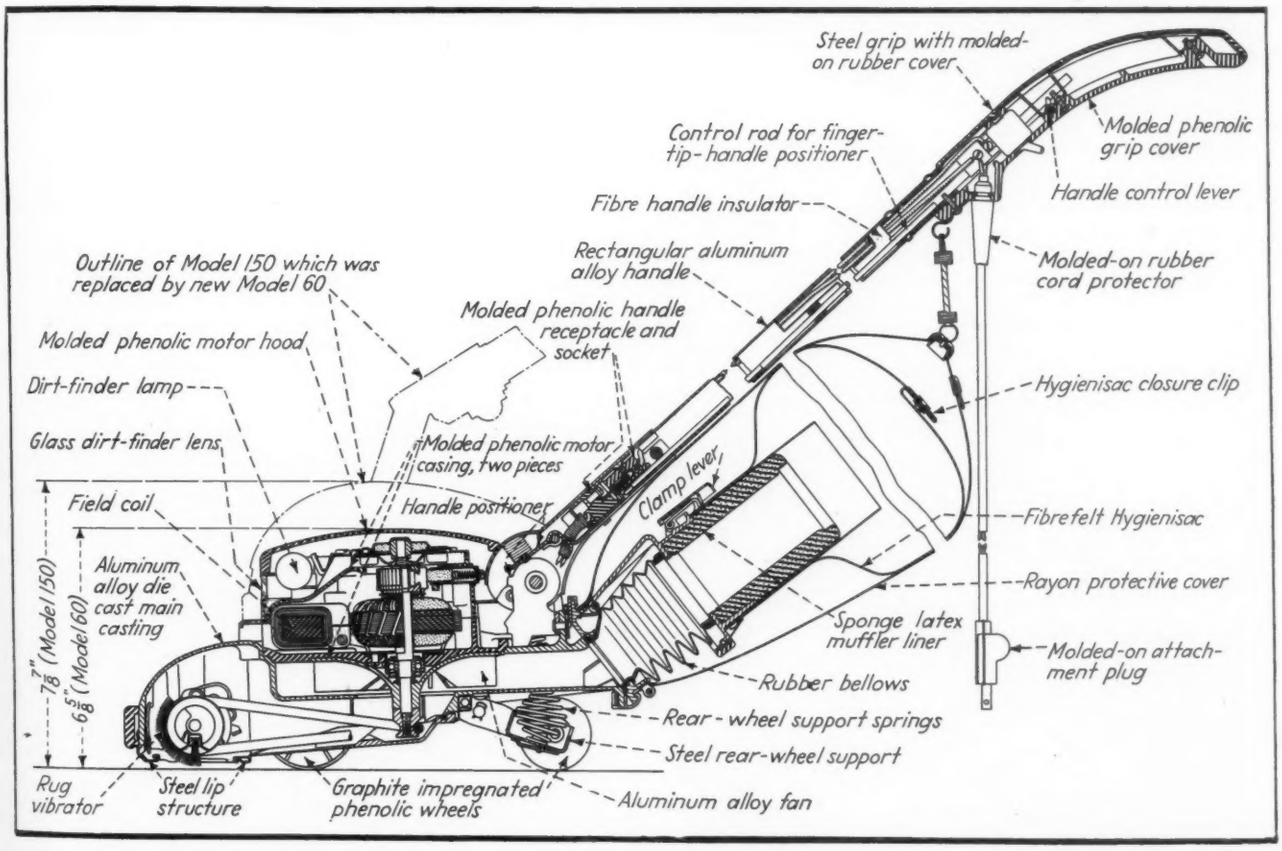
Destroyable Bag Assembly
(Rear View)

Two types of bags are provided, one a standard cloth bag made from Filtaire fabric, equipped with an exhaust muffler and a reinforcing frame in the upper end for easy emptying. The second bag is a destroyable unit consisting of a Hygienisac made of Fibrefelt, fitted with a rayon cover.

Muffler in cloth bag assembly consists of a sponge latex liner reinforced with a spring wire coil, and covered with sheet rubber. This provides flexibility necessary to allow movement of the handle and bag. A self-closing valve is placed on the end of the muffler to prevent dirt from escaping from the lower end of the bag when it is being emptied. The entire unit is fastened to the cleaner by a die-cast bag flange.

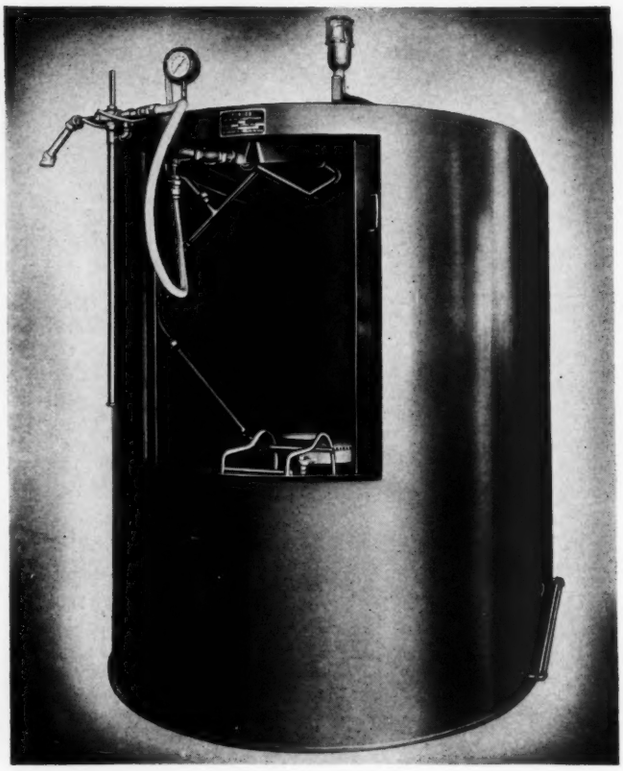
The muffler assembly for use with the destroyable bag also has a sponge latex muffler liner. Flexibility is provided by two castings hinged together and connected by means of a rubber bellows. The muffler liner is inclosed by an aluminum alloy tube which also acts as a pilot when installing the Hygienisac. The clamping mechanism for the Hygienisac can be seen on the outside of the aluminum tube. Molded sponge latex was found to fulfill all requirements for the muffler liner provided that the density of the material was held within close limits.

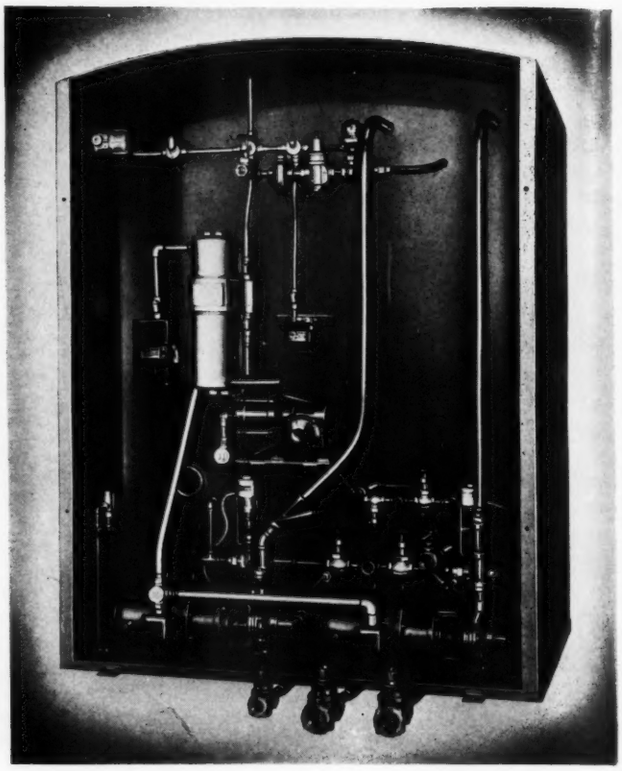




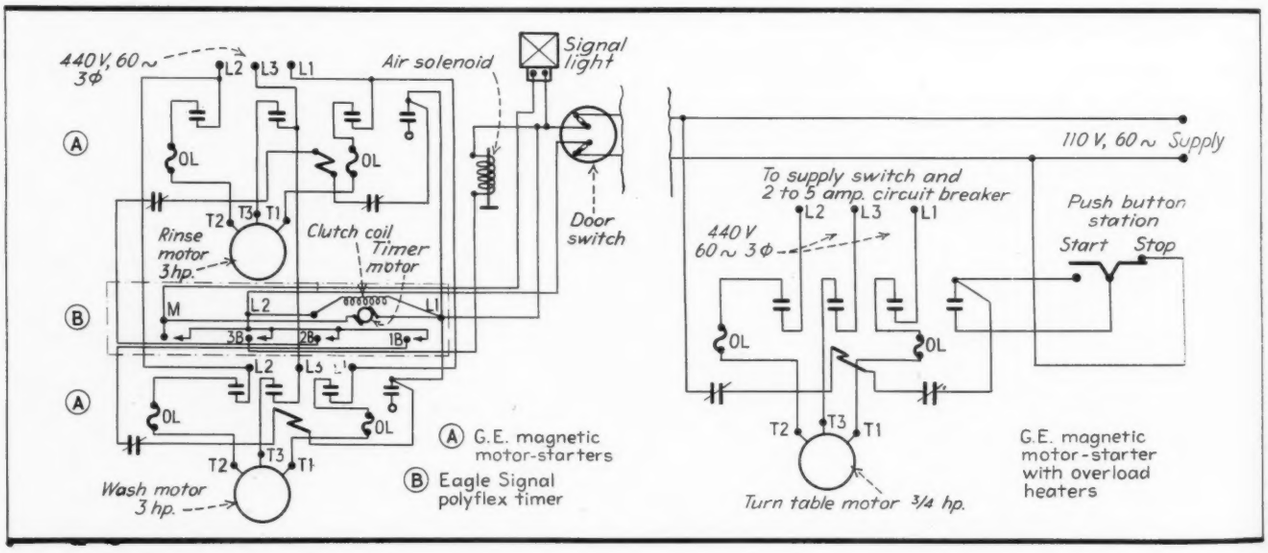
1¼ in. reduction in height was accomplished in redesign. The dotted outline represents the Hoover Model 150 replaced by the new cleaner. The greatest amount of this reduction was achieved through redesign of the motor. The single field coil is wound on the base of "U" allowing field coil to be placed in a position such that it does not interfere with other parts of the motor. Thus the commutator, brushes and ventilating system could be lowered. The larger diameter armature on Model 60 permitted the field stack to be reduced in height from 0.9 in. to 0.6 in. Height was further reduced by pivoting the handle socket at the rear. The handle can be lowered parallel with floor, in this position socket will be level with motor hood. Dirt-finder lens is of heat-resistant glass.

MODERN DESIGNS — Drum Reconditioner



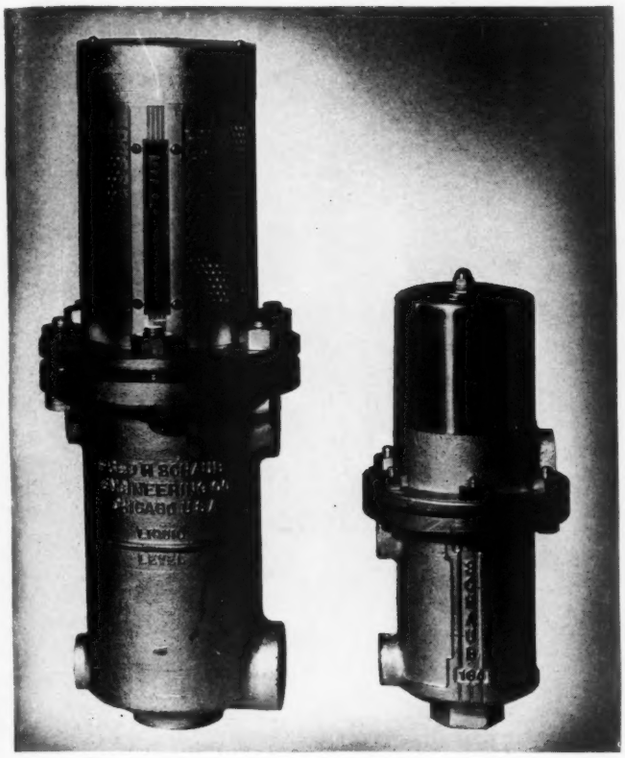


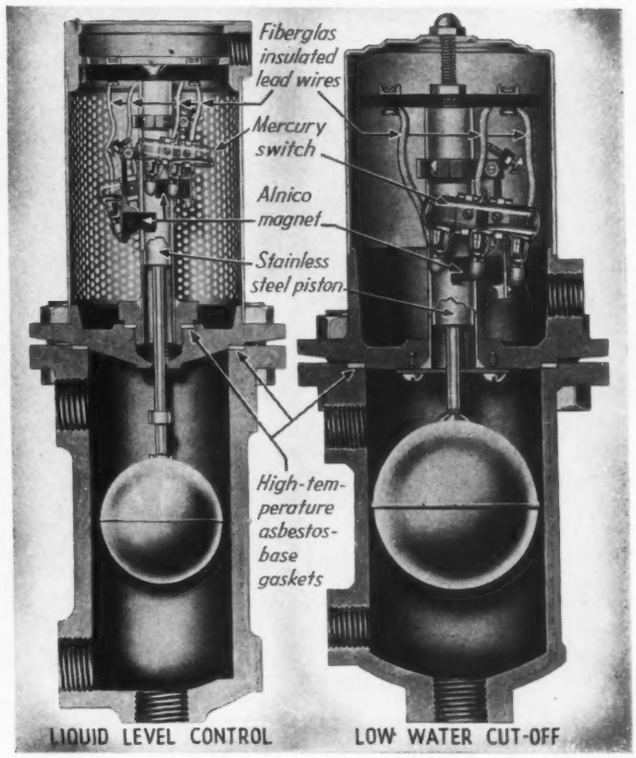
Cleaning oil drums involves application of heated wash solution on the outside to remove paint and dirt, and washing on the inside to remove oil, followed by hot rinsing, and air drying. This cycle is accomplished automatically in the Portco reconditioner. The steel plate shell has welded partitions which form the compartments for washing and rinsing solutions. Stainless steel fittings are used in the caustic and rinse lines. Cleaning and rinsing solutions are heated by steam; temperature is maintained automatically by an American Regulator controller. Wash and rinse pumps are Ingersoll-Rand, direct connected to General Electric explosion-proof 3 hp. motors.



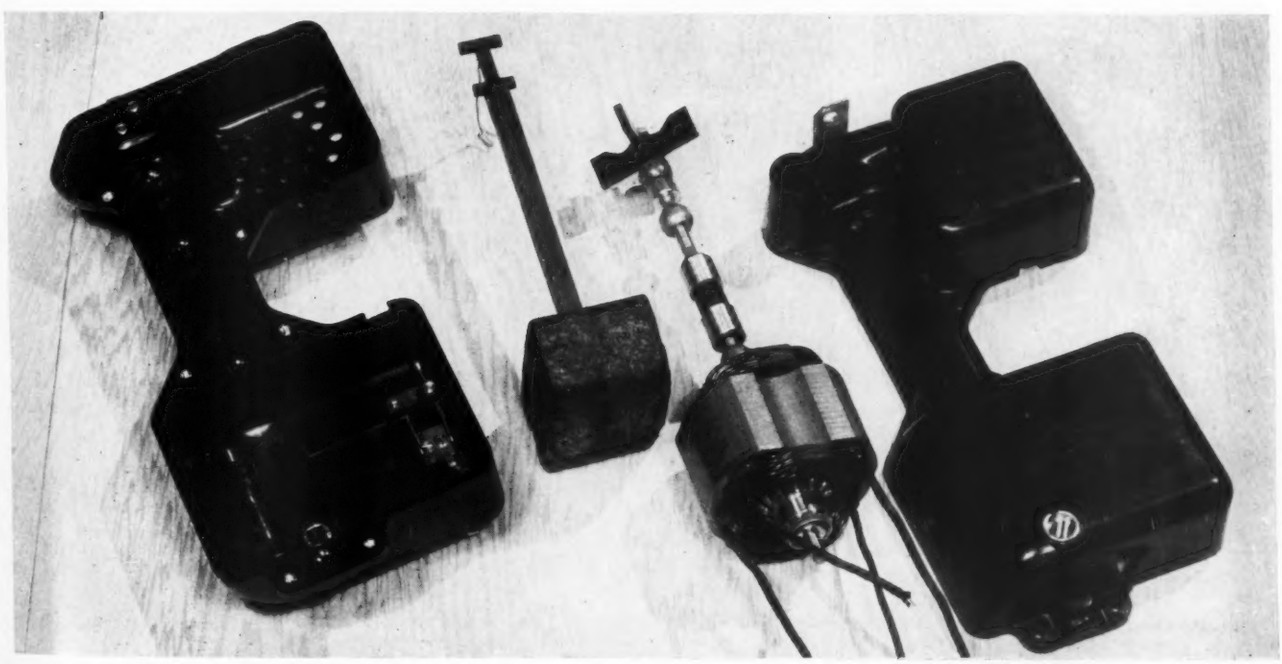
Cleaning operation. The drum is placed in the cradle and the combination spray and siphon is inserted in the bung hole, and the drum is tilted to an upright position. Closing of door automatically operates a switch which energizes the timer controlling the pumps, air solenoid, and signal light. Heated wash solution is then sprayed simultaneously on the drum outside and interior. The solution is siphoned from the interior by suction created by the entering solution. When washing cycle has been completed the timer stops the wash pump and trips the air solenoid to siphon out any solution remaining in drum. Rinse pump is then energized. After rinsing, drum is air-dried.

Float Actuates Switches Through Alnico Magnets



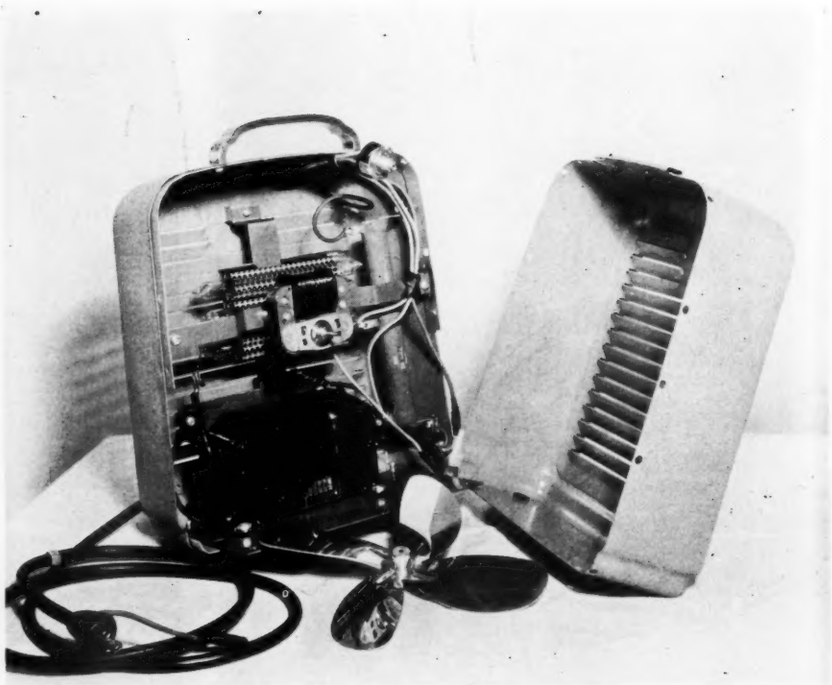


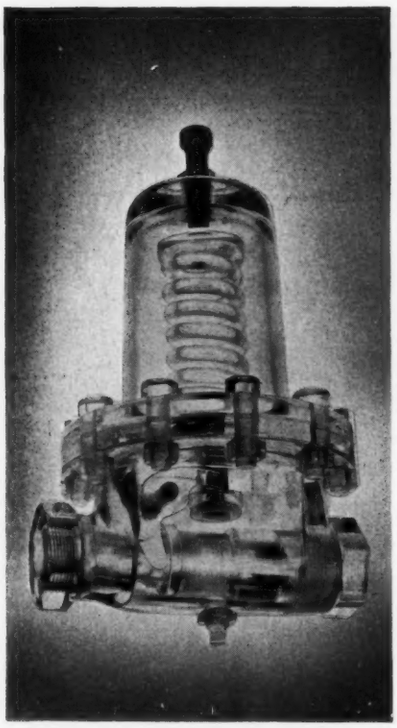
Switching action in the Schaub Magnetrol is obtained through the rise and fall of a 0.17 chromium, stainless steel piston attached to a monel float. The piston slides in a hard-drawn, seamless copper tube. As the piston reaches a predetermined level in the tube, it comes into a permanent magnetic field produced by an Alnico magnet. Thus the magnet moves in toward the piston, tilting the mercury switch mounted on the magnet arm. The mercury switches are connected by glass-insulated wire. High-temperature, asbestos base Garlock gaskets are used.



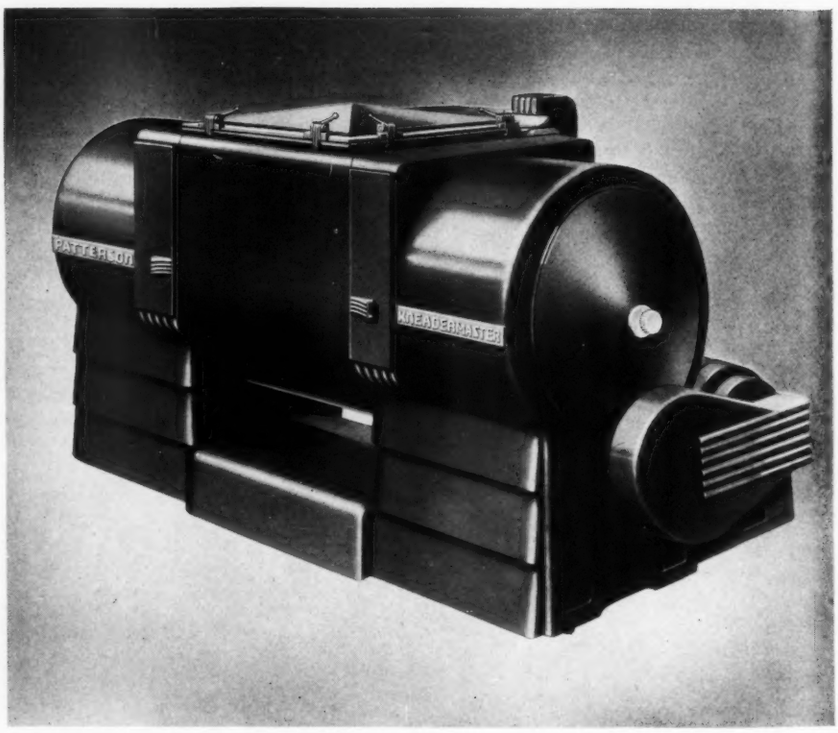
Molded of water-resistant plastic, the housing of the Geo. W. Fleming bilge pump is not subject to corrosion or electrolytic action. Construction includes stainless steel armature shaft, monel metal rivets, tungsten contacts, Chamet bronze switch parts, plastic and hard rubber float. Housing is molded of a Durez plastic.

Oxygen generating machine for home use, designed by Ray-O-Zone Corporation, produces an ultra-violet corona which delivers enough oxygen to destroy impurities in a space of 5,000 cu. ft. Fan is mounted in the 16-gage steel two-piece cabinet. Average 110 volt current consumption at normal rates is 30—40¢ per month. Styled by Barnes and Reinecke.

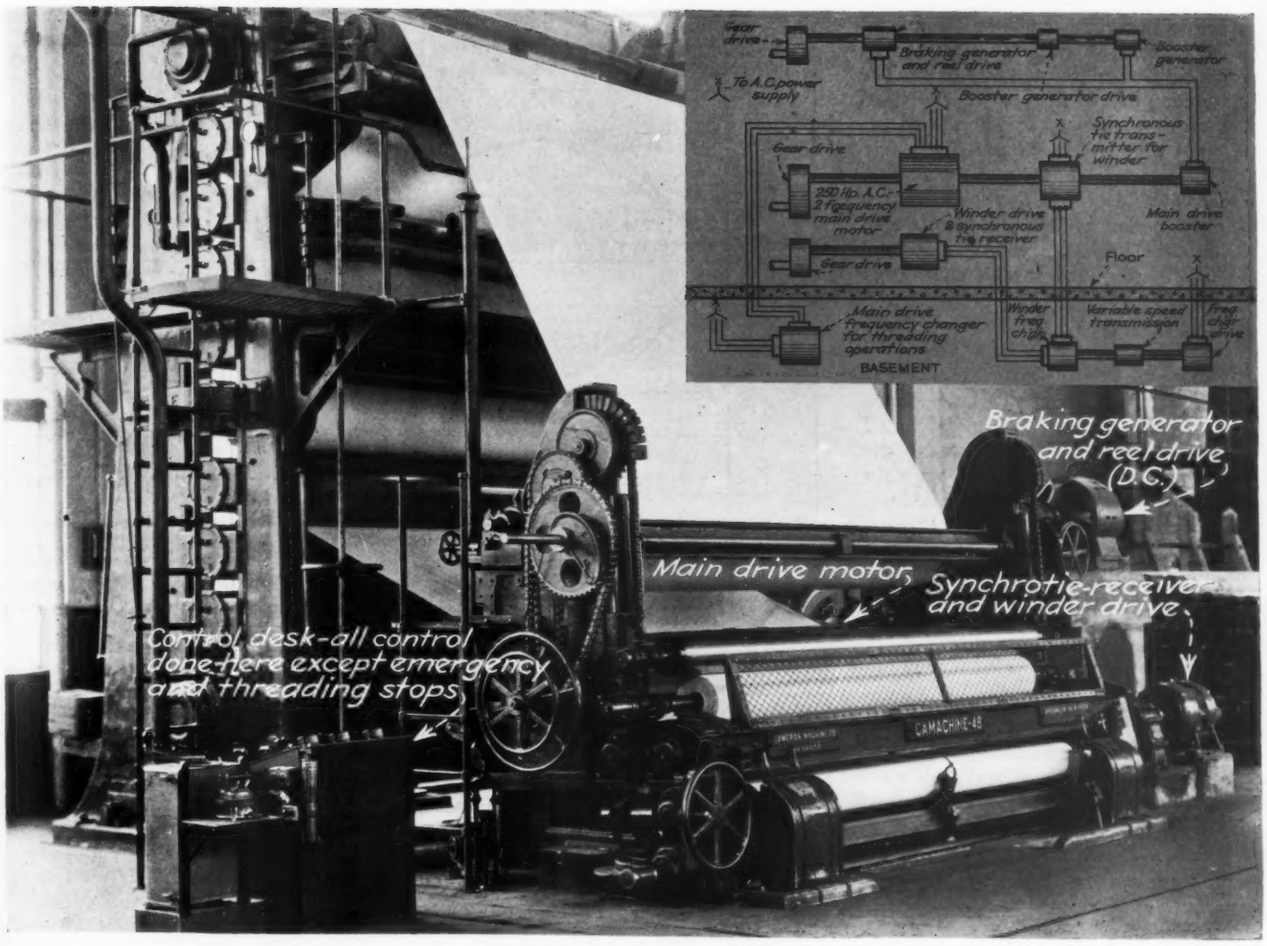




Transparent valve, fabricated of Lucite and Plexiglas by the Dave Swedlow Corporation, is an exact scale model for sales purposes of an A. W. Cash Company streamlined pressure-reducing valve. It is ten inches high.



Kneadermaster mixer, developed by Patterson Foundry & Machine Company, is driven through helical-cut, wide-face gears, automatically lubricated, and inclosed in oil-tight housings. Mixer body is mounted on oversize center trunnions. Dumping is accomplished by means of a high-starting torque, low-starting-current motor built into the machine, pushbutton controlled. Blades can be cored for circulation of heating or cooling mediums.



To maintain paper tension, winder motor is receiver in synchrotie system, transmitter is direct-coupled to main drive

SYNCHRONIZED DRIVES

Features and Applications of Synchrotie Systems

C. W. DRAKE
Westinghouse Electric & Manufacturing Company

TWO OR MORE machines or units can be made to turn or move in unison either by means of a mechanical tie such as shafts, gears and chains, or by having a wound-rotor induction motor, connected in such a manner that any rotation of the armature of one of the motors causes an equal rotation of the armature of the other motor. The term "synchrotie" has been adopted to denote such a combination of suitably connected wound-rotor induction motors.

There is a close analogy between an electrical "synchrotie" system and a lineshaft or mechanical transmission connecting two machines. Both a synchrotie and a lineshaft will transmit torque or power and after steady running conditions have been established, in both cases the delivery end of the transmission will make exactly as many revolutions as the receiving end. Just as in the mechanical transmission the shaft will twist upon application of the torque to be transmitted and thereby cause an angular difference between the two ends of the shaft, so also is there an angle of lag in the synchrotie system. In the case of the shaft transmission the amount of angular twist depends upon the torque transmitted, the diameter of the shaft and the length of the shaft. In a synchrotie drive the angular difference between the two units is a function of the size of the motors and the torque transmitted.

In general, where power is transmitted by any combination of shafts,

gears or other mechanical units, the same results can be accomplished by a properly designed synchrotie drive. The more complicated the mechanical drive, the more pronounced will be the advantages of the electric system.

In its simplest form a synchrotie drive consists of two duplicate wound-rotor induction motors as shown in Fig. 4, with the primaries connected to the 3-phase power supply and the rotors connected together. When properly connected or phased out, the machines remain stationary when line voltage is applied, and there is no current in the rotor circuits. When one unit, called the transmitter, is turned, the small phase displacement between it and the other unit, called the receiver, causes a current to flow between the machines, thus developing torque or turning moment.

Many of the problems involved in the application of synchrotie drives are similar to those encountered in the application of induction motors, such as the consideration of starting and maximum torques, maximum operating speed or speed ranges, load torques over the speed range and the motor temperatures that may result. There are, however, certain factors which are peculiar to the synchrotie system and which must be carefully considered in making applications. Some of the more important or common factors are explained in this article.

Fundamental Factors

SYNCHRONIZING. The two units must be synchronized or connected to the line when both are at a standstill. If operating requirements do not permit the stopping of both sections of a machine for synchronizing, a friction clutch may be used between the receiver and its load or between the transmitter and its drive so that the synchrotie is energized at all times.

DIRECTION OF ROTATION. With both units energized from a polyphase source, if the transmitter is driven in the direction it would normally run as a motor, the tie is said to operate "with the field." If the transmitter is driven in the opposite direction, the tie is said to operate "against the field." For each of these conditions the receivers operate in the same relation to the field as the transmitters, the relationship being referred to their normal rotation as motors. Each rotation has certain advantages and limitations.

MAXIMUM SPEEDS WITH THE FIELD. When operating with the field the maximum speed must not exceed two-thirds of the synchronous speed of the unit, that is, 1,200 r.p.m. for 4-pole, 60 cycle motors. The synchronizing torque decreases rapidly above this speed, and maximum speeds below 1,200 r.p.m. may frequently be required in cases of pulsating or fluctuating loads.

MAXIMUM SPEED AGAINST THE FIELD. When operating against the field, speeds up to or above synchronous speed are permissible. At synchronous speed the frequency in the rotor is twice the line frequency, thereby causing higher rotor losses. Another limitation to this method of operation is that in case of overload or the tie pulling apart the receiver tends to reverse and run as a motor at synchronous speed in the opposite direction. Under similar conditions, when running with the field the receiver speeds up in the same direction.

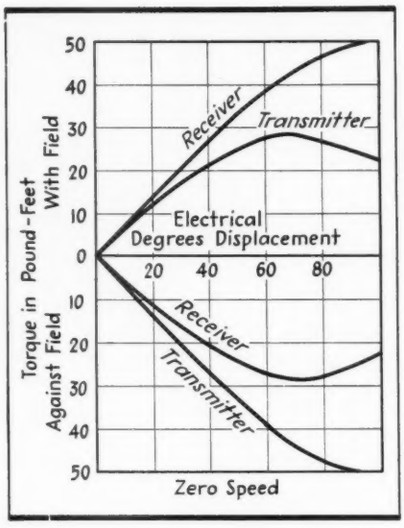


Fig. 1 — Characteristic torque-displacement curves for two 5 hp., 4-pole, wound-rotor synchrotie motors operating at zero speed

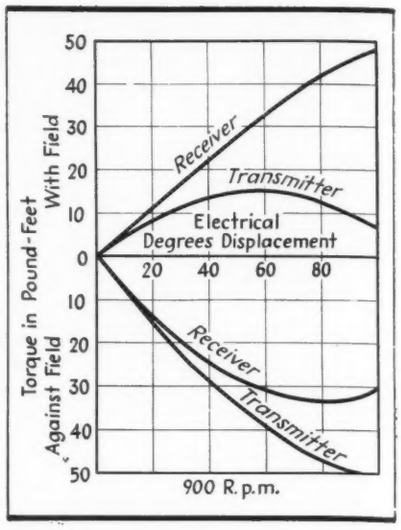


Fig. 2 — Characteristic torque-displacement curves for two 5 hp., 4-pole, wound-rotor synchrotie motors operating at 900 r.p.m.

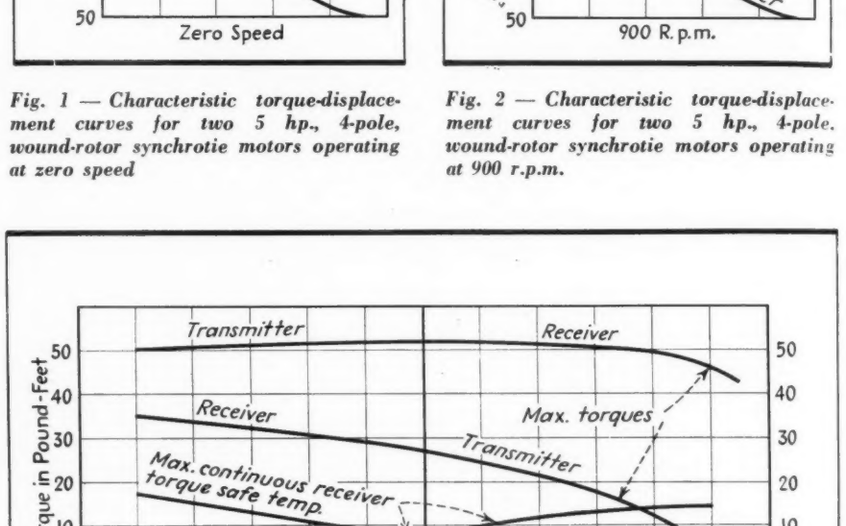


Fig. 3—Maximum torque values available at various speeds using two 5 hp., 4-pole, wound-rotor motors for the synchrotie units

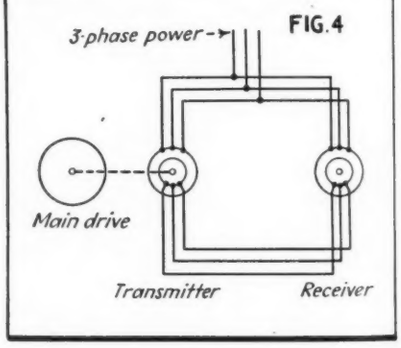


Fig. 4—Simplest form of synchrotie drive consists of two duplicate wound-rotor induction motors with one tied mechanically to the driving motor

DISPLACEMENT ANGLE. The mechanical degrees displacement between the two units is equal to the electrical degrees divided by the number of pairs of poles per unit. For instance, if two 4-pole units for a given torque operate at a displacement of 20 electrical degrees the mechanical angle would be one-half of twenty or 10 degrees, since there are two pairs of poles. Angular displacement is seldom of much importance on drives which run continuously or on which large gear ratios are employed, but it may be of vital importance when used as position indicators operating in both directions.

SYNCHRONIZING POSITIONS. Two-pole machines will synchronize in one position only and consequently are required for position indicators and similar applications. Four-pole units synchronize in two positions, 6-pole in three; the number of positions always being one-half the number of poles.

CHOICE OF NUMBER OF POLES. As a rule, units of 4-pole construction are used so that operation with the field up to a reasonable speed, of the order of 1,000 r.p.m., is possible. Two-pole designs may be required for certain applications but are more special and expensive. For applications requiring a smaller angular displacement, six or eight pole machines may be necessary. When it is desired to operate the transmitter and receiver at different speeds, the use of a different number of poles on the two units may prove advantageous instead of using gearing or mechanical speed changers. For instance, if the transmitter has six poles and the receiver two poles, the receiver speed will be three times that of the transmitter. Thus a transmitter speed of 1,600 r.p.m. (against the field) gives 4,800 r.p.m. receiver speed, an application now in use on wire insulating machines.

SPEED-TORQUE CURVES. In Figs. 1, 2 and 3 are shown characteristic torque-displacement curves of synchrotie units, the values in this instance being those obtained when using two 5 hp., 4-pole, wound-rotor motors. In Fig. 1 the values are with both units at zero speed, while in Fig. 2 the units are operating at 900 r.p.m., that is, one-half of synchronous speed. In Fig. 3 are shown the maximum torque values available at various speeds, also the torque which may be carried continuously with a safe temperature rise of 50 deg. C. At 900 r.p.m. a torque of approximately 12 ft.-lb. can be carried safely, and by referring to Fig. 2 it is seen that this corresponds to a displacement angle of approximately 20 electrical degrees or 10 mechanical degress, in this particular case. In other words, if worked at a load to give the maximum temperature rise, there would be about 10 degrees difference between the transmitter and the receiver. For reversing service this may or may not be important, depending on the gear reduction and the accuracy required. If geared down with a 20 to 1 ratio there would be a variation of plus or minus ½ degree for full load torque and proportionally less for lighter loads.

From Fig. 1 it is seen that the maximum receiver torque when operating with the field is approximately 50 ft.-lb. as compared with 30 ft.-lb. in the opposite direction. Consequently for reversing service the minimum value must be used for calculations of starting torque, acceleration, and similar factors. The starting torque required by any machine is a fairly definite figure, but the accelerating torque is a function of the inertia and rate of acceleration. In the case of a synchrotie drive the acceleration and deceleration or braking are determined by the main drive. Ordinarily, no difficulties are encountered along these lines, but if the load driven by the receiver has a high inertia and the main drive is a linestart squirrel cage motor with a low inertia load, trouble might be encountered.

Example of Application

A simple application of synchrotie drive is the feed mechanism of a machine which requires 1 hp. at 100 r.p.m and constantly the same torque down to a speed of 10 r.p.m. The transmitter can be driven from the main drive motor at a speed of 1,000 r.p.m. and would consequently operate at speeds from 1,000 down to 100 r.p.m. The most economical arrangement is to operate the receiver also at 1,000 r.p.m. and by means of gearing reduce the speed to 100 r.p.m. Gearmotors work out highly advantageously for such drives.

Assume the use of 4-pole machines, that is 1,750 r.p.m., 60 cycle, wound-rotor motors. Then 1 hp. at 1,000 r.p.m. would correspond in torque or frame size to 1.75 hp. at 1,750 r.p.m. On this basis a 2 hp. motor might be chosen to deliver 1 hp. as a synchrotie at 1,000 r.p.m., but since the same torque, that is, the same amperes in the rotor, must be carried down to a speed of 100 r.p.m. or 1/18 of the synchronous speed, it is evident that either a larger motor or forced ventilation must be used in order to maintain a safe temperature at the minimum speed. If the tie is energized for any length of time at zero speed, this also must be taken into consideration, but the control can usually be arranged to disconnect the tie when the main drive is shut down. Depending on the load conditions, inclosures, ambient temperatures, etc., either a 3 hp. or perhaps a 5 hp., 4-pole frame size would be needed if forced ventilation is not used.

Numerous modifications of the simple drive shown in Fig. 4 may be made, and some of the more common are illustrated in Figs. 5, 6 and 7. Two or more

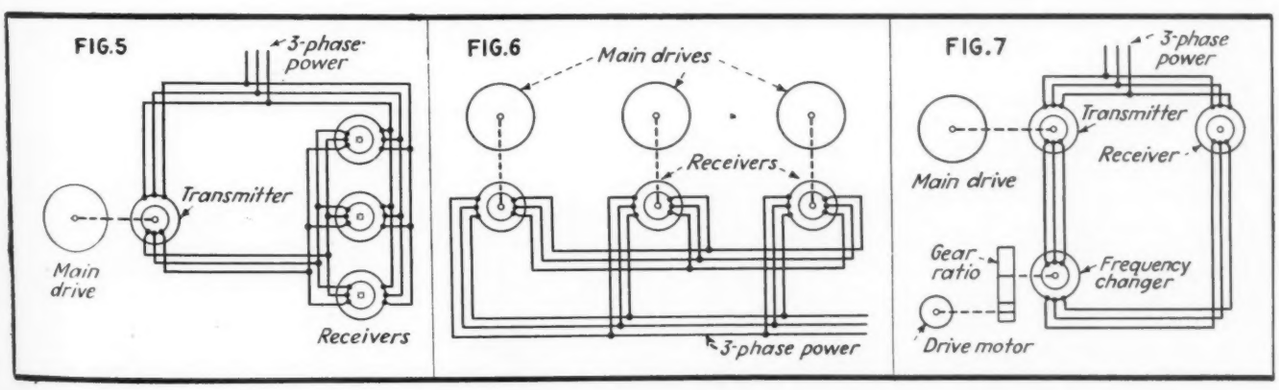


Fig. 5—Two or more receivers can be operated from one transmitter as shown in this schematic diagram. Fig. 6—An arrangement frequently used for large capacity drives where power is supplied to each section and the synchrotie drive is used only to hold the main drives together. Fig. 7—By adding a frequency changer in the rotor circuit of a single synchrotie drive the speed of the receiver relative to that of the transmitter can be increased or decreased

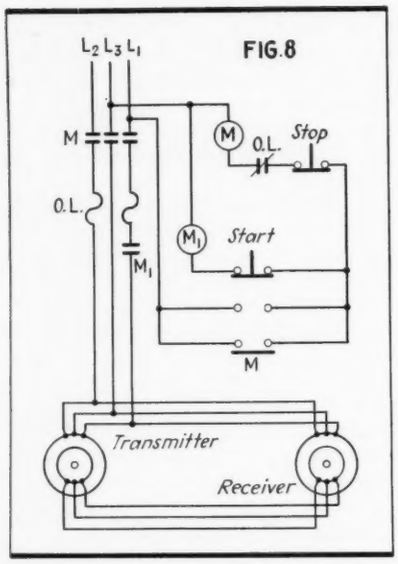


Fig. 8—A simple and inexpensive manually controlled scheme for applying single-phase to bring rotors approximately in phase and then connecting to the three-phase power

receivers can be operated from one transmitter as shown in Fig. 5, and although they may be of different ratings and speed, (number of poles) they must be specially designed for such a connection. The transmitter must be of sufficient capacity to supply the combined load or torque of all the receivers. Such an arrangement may be advantageous for synchronizing various portions of one machine or synchronizing the operation of several independent machines.

The arrangement in Fig. 6 is frequently used in drives of large capacity where power is supplied to each section, and the synchrotie drive is used to hold the main drives together. The rating of the tie unit is determined by the unbalanced load or torque between the main drives, and any tie unit may operate either as a transmitter or a receiver depending on the load conditions. Bascule or lift bridges often use such an arrangement, and as a matter of insurance the tie units are frequently of sufficient capacity to operate one side of the bridge alone in case of failure of one of the main units. In an emergency each of the two main motor drives must be of sufficient capacity to operate the entire bridge using only one of the two main motors.

In Fig. 7 is illustrated the addition of a frequency changer in the rotor circuit of a single synchrotie drive in order to increase or decrease the speed of the receiver relative to that of the transmitter. The frequency changer consists of a wound-rotor motor of similar size and characteristics to the tie units, together with suitable gearing and driving motor so that it can be rotated at a low or variable speed. If all of the tie units have the same number of poles and the frequency changer is rotated at a speed of 1 r.p.m., the speed of the receiver will be increased or decreased by 1 r.p.m. depending on the direction in which the frequency changer is driven. At zero speed the frequency changer has no effect on the speed of the receiver, but its connection in the electrical circuit reduces the torque available quite materially and the entire drive must be estimated on this basis. The frequency changer is in effect an electrical differential and various arrangements of the drive and control of its driving motor are possible to meet specific conditions. For instance, with the transmitter at a standstill it is possible to rotate the receiver at the same speed as the frequency changer for making machine adjustments, taking up slack, and for similar purposes.

Control of Synchrotie Drive

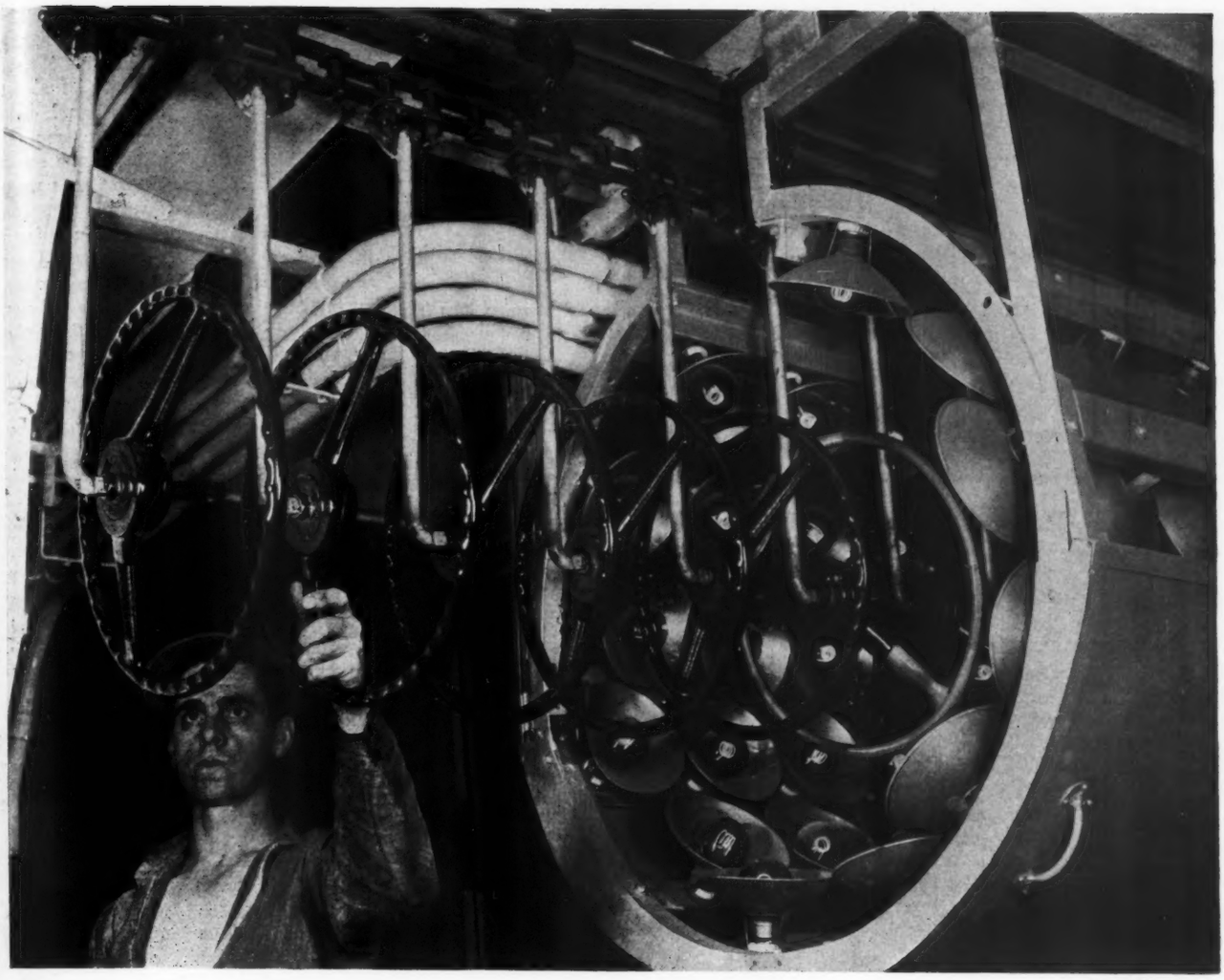
Even with the tie units at zero speed when connected to the line, it is frequently found that if 3-phase power is applied the units will not synchronize if their rotors are displaced at too great an angle, thereby causing one or both of the units to operate as a motor, tending to run to synchronous speed. If the load driven by the receiver is mostly friction, such as conveyors and feeding devices, the application of 3-phase power is frequently satisfactory. But to insure synchronizing under all conditions it is recommended that single-phase be applied first in order to bring the rotors approximately in phase, and then 3-phase power be connected. This sequence can be made automatic if necessary, but a simple and inexpensive manually controlled scheme is shown in Fig. 8. This consists of a standard linestarter with an additional contactor for opening one phase, together with a pushbutton using upper and lower contacts. When the button is depressed the linestarter is closed and held in, applying single-phase to the drive, and then when the button is released the second contactor closes, connecting the third phase to the line. A slow operation of the button, that is, a second or two, is usually sufficient. As an approximate rule it can be stated that the size of the linestarter may be chosen as that suitable for the motor rating used for the transmitter only. That is, if a 5 hp. motor rating is used for the transmitter to supply one or more receivers, then a 5 hp. starter would be used. The above approximate rule applies only when 3-phase power is used. But with single-phase excitation, which is also satisfactory in certain cases especially with smaller ratings, the size of the starter will be approximately twice as large, that is, equal to the sum of the ratings of the transmitter and receiver.

Although separate control can be supplied for the synchrotie as shown in Fig. 8, it is frequently desirable to design and build the control for the main drive and the tie together so that suitable interlocking is obtained. It is thus possible to arrange the circuit so that the tie must be closed before the main drive can be started. If desired, it can also be arranged so that the stop button of the synchrotie is inoperative when the main drive is running or the tie cannot be disconnected until a definite time after the main drive has stopped.

One feature obtainable with a synchrotie drive which is not possible with mechanical transmission is the independent operation of the receiver as an induction motor with rotor resistance. Such operation is frequently desirable in making machine adjustments or setting up work. A double-throw arrangement of the control circuit transfers the connections of the receiver from the transmitter to a suitable resistor or control equipment.

Typical Synchrotie Applications

Bottle making machines and discharge conveyor
Textile range drives in finishing and bleaching plants
Kiln and kiln feeder in cement plants
Screwdown control in steel mills and bascule and lift bridge drives
Marine way using individual drive for each chain
Paper supercalender and winder and paper coating machines
Linoleum calender and conveyor
Remote operation of belt shifters and remote operation of valves
Wire insulating machines—both rubber and paper
Feed drives on boring mills and other machine tools



Ford Motor Company

Battery of infra-red drying lamps for baking finishes on automobile steering wheels

INFRA-RED LAMP BANKS

For Drying Finishes and Materials

HEAT as produced by the radiant energy in the short wave lengths in the infra-red range of the spectrum is being utilized widely for drying finishes, moisture drying, softening of plastic materials and for other processes requiring heat. First applied a few years ago by the Ford Motor Company to the drying of automobile finishes, many experimental and production installations have since been made. Experiences gained from these pioneer projects point the way to certain advantages and limitations in the application of infra-red heating to many production and design problems.

Incandescent bulbs arranged in various ways furnish the energy for infra-red drying. Both tungsten and carbon filament lamps are used. Originally the standard lamp size was 240–260 watts. Recently tungsten lamps of higher capacity, 500 and 1,000 watts, have been announced for this process. About 90 per cent of the input power of these lamps is emitted as infra-red energy. Wave length depends on the operating temperature of the light source. Generally, the maximum energy distribution of these lamps occurs at wave lengths of about 11,000 to 14,000 Angstrom units (0.0000011 to 0.0000014 meters long) depending on the type. The operating temperature attained gives a good balance between maximum penetration obtainable at high temperature-short wave lengths and maximum absorption at low temperature-long wave lengths.

Reflection factors for various materials used in incandescent bulb high-temperature sources to reflect radiant energy are listed in Table I. Generally

Table I—Characteristics of Different Types of Reflectors

Material	Approximate Reflectivity Per Cent	Comments
Gold	95	Subject to fouling from certain volatiles which emanate from lacquers
Aluminum (processed)	90	Durable, easily cleaned surface with good resistance to volatiles
Aluminum (polished)	65–88	Reflectivity varies with wave length of radiation. Oxidizes rapidly
Chromium plating	60–80	Low reflection factor in the 10,000 Angstrom region
Silver	Good	Rapid tarnishing or oxidation in ordinary atmospheres
Copper	Good	

Table II—Hardening Characteristics of Finishing Materials

Material	Baking Temperature	Comment
Synthetic enamels: alkyd synthetic and urea-formaldehyde modified synthetics	250–350 deg. F. (1.75–2.0 watts per sq. in.) 350–400 deg. F. (about 2.8 watts per sq. in.)	Harden by polymerization and/or oxidation. Oil modified resin is used as the vehicle. Response to infra-red treatment depends on pigments and color
Lacquers	100–150 deg. F.	Harden by evaporation. Since they are dried at low temperature to avoid pinholing and bubbling no discoloration will occur. Formerly air dried because of the low temperatures
Wrinkle finishes	150–450 deg. F.	More difficult to bake out because of the high temperatures required and/or time required for oxidation
Japans		Baking japans have not proved economical for this method of drying as the vegetable oils which they contain harden too slowly. Air-drying japans offer no difficulty

reflectors are of two shapes, either parabolic for general purposes or a deeper bowl shape for providing concentrated and more uniform light. The temperature on the surface to be treated is dependent on the following factors:

1. Radiant energy per unit area. Tests indicate that a concentration of 6 watts per sq.in. on 20 gage black painted sheet steel will give a temperature of 500 deg. F. in 5 min. while a concentration of 2 watts per sq.in. will give a temperature of only 280 deg. F. in the same time. Concentration of energy depends on the wattage of the lamps, as well as the design and spacing of the reflectors.

2. Distance from lamp to surface. Amount of heat at the surface of the part varies inversely as the square of the distance to the lamp. In commercial practice this distance is usually 6 to 18 in., depending somewhat on the time the pieces stay under the lamp.

3. Reflection factor of the surface being treated. The higher reflectivity factors, such as that which white enamels or paints have, tend to slow up the rate of drying because insufficient energy is absorbed. Reflection factors vary with change in the wave length of the infra-red. Table III indicates this variation for some pigments.

4. Mass of the material. Too large a mass with limited surface presented to the rays will cause heat to be conducted away from the surface and retard the drying of the finishes. However, this factor is useful when baking cores or motor armatures. Tests on sheet steel panels painted black indicate that thickness has an appreciable effect on the "heating-up" time. In 4 min. a 14 gage panel reached a temperature of about 230 deg. F. while a 20 gage panel, only about half as thick, reached a temperature of about 260 deg. F. in the same time. In 8 min. the temperatures were 300 to 325 deg. F., respectively.

If the baking time is sufficiently long the mass is heated through and from then on the thickness of the piece has no further effect. However, with finishes which have a short baking time the thickness has a definite effect on the production rate since a large percentage of the total heating time is consumed in bringing the heavier gages up to drying temperatures.

Other miscellaneous factors which affect the temperature and the rate of drying because of their effect on the rate of reaching working temperatures are: the specific heat and conductivity of the material; heat losses from low temperature radiation by the work; effect of air currents or drafts; conduction to backing or supporting members; area presented as a "target" for the rays; film thickness and type of finish.

While the cooling effect of drafts should be kept to a minimum a certain amount of air movement is required to keep the volatiles from reaching inflammable concentrations. With proper technique there is no danger of explosion.

The area presented to the lamps is sometimes not sufficient to get economical results in terms of the power consumed. Even for parts having large surfaces it is necessary to present as large a percentage of the total area of the part to the energy source as possible by proper lamp or conveyor arrangement. Parts with recesses may cause difficulty because they heat unevenly or because the radiant energy does not reach all the areas to be dried. Sometimes unexposed flanges, knobs or other projections will dry by conduction. Unusual applications must be solved by trial.

Wave length is important to the extent of its bearing on the reflectivity factors. Generally the reflection factor of polished surfaces on most metals increases with an increase in wave length. Paints, enamels and papers have similar tendencies. The wave length can be increased by decreasing the temperature of the radiant energy source.

The reflection factor of the metal to which the finish is applied influences the temperature attained only to a small degree. Some of the energy impinging on the surface tends to go through the paint film, the amount reflected back by the metal depends on the degree of polish the metal may have. The reflected energy may be absorbed on the way out but some will escape. The

"thermal capacity" of the metal, which takes into account both the specific heat and the mass, may in some conditions have an appreciable effect on the temperature attained.

In general air-dry finishes are satisfactorily handled by infra-red drying at temperatures not exceeding 150 deg. F. Synthetic enamels and wrinkle finishes require higher temperatures. Temperatures as high as 600 deg. F. have been satisfactory for baking wheel finishes.

All synthetic enamels do not respond to infra-red drying to the same degree. Some tend to "yellow" because of the actinic property of the light although a hard finish may be secured. Discoloration may occur if the temperature under the lamp is allowed to exceed the baking temperatures. Most of the organic pigments are sufficiently stable to be heated successfully, if careful control of temperature is exercised. Some finishers have found that the substitution of inorganic substances for the organic pigments is a solution to the problem of control.

In so far as the other constituents of enamels are concerned, some of the resins in the finish may cause no particular trouble. Of all the resins, those made from urea-formaldehyde are most successful as they are heat-hardening and require no oxidation to cure them. Modified alkyd urea gives a tough surface rapidly. Speed of baking depends somewhat on the oils introduced to modify the resins; perilla and tung oil have been found to be satisfactory. Soya oil vehicles usually dry too slowly for the infra-red method.

Experiments in drying oil-base paints, similar to house paints, were unsuccessful when application to farm equipment and to wooden toys was attempted. Oil paints and oleo-resinous materials in general cannot be baked rapidly enough under infra-red lamps because they require considerable oxidation thus making other methods of drying more economical.

Some of the problems mentioned may be solved by future advances in the methods of application. According to David Aitken, Cleveland Electric Illuminating Company, "the drying of synthetic wrinkles is probably accomplished better by properly applied radiant energy than by any other method. I have several successful installations drying in 8 to 15 min. wrinkles on sheet and aluminum or zinc die cast parts.

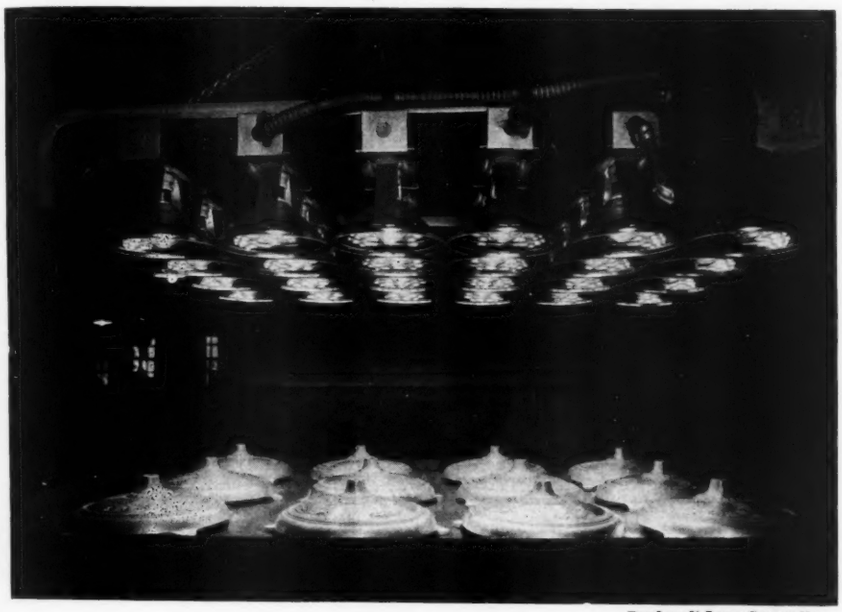
"While normally the oxidizing bake of oleoresin finishes is not associated with infra-red and speed, nevertheless in several applications long oil materials have produced excellent results when run through a lamp oven. In several examples oleoresins that normally required 250 to 275 deg. F. for two hrs. in a conventional oven were baked successfully on 18 to 22 gage stock, in 12 to 20 min. under a density of only 1.6 watts per sq. in. and 275 deg. F. metal temperature.

"Many of the new spatter and opalescent finishes react readily under lamps with a normal cycle of 6 to 10 min. depending on gage and type of material.

"In my own opinion I see no reason, granted that proper technique in applying lamps is used and with proper control of convected air, for going to greater intensities than 2 watts per sq. in. for most enamels, and to more than 325 to 350 deg. F. on 18 to 28 gage metal for a good, uniform cure. I have experimented with watt densities up to 8 watts per sq. in. and 800 deg. F. on metal, and believe that it is better to lower the connected k.w. and to have only a slightly longer time cycle and thus avoid brittleness or shortness of film after baking."

As indicated in Table IV, the field of moisture drying has often presented problems which could not be economically solved by infra-red heating. The major successes have been where the moisture film is thin or the material to be dried is thin.

Only a few experiences are available on the expansion of metals. Ford has used infra-red heating in expanding pistons for inserting piston pins. One outboard motor manufacturer is reported to have used the method in making shrink fits. In the latter, concentrating type of reflectors were found better than the parabolic type. However, too much



Rembrandt Lamp Corporation

Drying lamp base castings by infra-red heat after pickling. Rapid drying time decreases possibilities of discoloration thus eliminating repolishing. Moisture and chemicals are removed from deep recesses which formerly had a tendency to erupt through the lacquer coat and thus spoil the finish

Table III—Reflectivity of Pigments

Pigment	Wavelength (Angstroms)		
	6,000	9,500	44,000
Cobaltic oxide — steel gray	3	4	14
Chromic oxide — dark green	27	45	33
Lead oxide — yellow	52	..	51
Ferric oxide — red	26	41	30
Lead chromate — yellow	70	..	41
Zinc oxide — white	82	86	8
Lead carbonate — white	88	93	29

time was required to do a satisfactory and economical job of assembly.

One advantage of infra-red heating over air or oven drying is that heat is instantly available with the lamps whereas some time is required to bring the parts and oven up to working temperature. The prime coat on the Ford bodies is baked in 15 min. with infra-red lamps as compared to 60 min. required by the steam oven which was replaced. Finishing coats require about twice as much time as prime coats with even greater saving over previous oven drying schedules.

However, direct comparisons of baking times between lamp ovens and conventional ovens may be misleading since often there are special conditions which favor one method against the other. To compare the baking times without taking into account the special factors involved may lead to erroneous conclusions.

Usually lacquers and quick-drying enamels can be very rapidly dried with lamps. Occasionally, however, it is just as difficult to eliminate the slight tack of synthetic lacquers as it is to bake a true baking enamel because of the time required for oxidation. The fast drying enamels best suited for lamp drying are made with short oil modified alkyd (glycerol phthalate) resins which may be further modified with urea-formaldehyde resins if greater hardness is desired. If high enough intensities are available, non-drying alkyd and urea-formaldehyde combinations are useful.

Since the varieties of finishes are almost endless and the effects of pigments, solvents and oils are often doubtful when exposed to infra-red heating, it is sometimes necessary to make trial installations.

Flexibility of infra-red heating is secured by cutting banks of light in and out as required by the number of parts on the conveyor line. Lights are adjustable in any direction. In many installations the distance of the lamps from the parts is adjustable for the full effective range of the lamps, that is, 6 to 18 in.

Infra-red drying lends itself to portability. Small banks of reflectors are mounted on rollers and used for spot drying of finishes in both automotive and aircraft manufacture and maintenance.

Infra-red heating is so new that changes are taking place rapidly. Drying times of finishes have been improved. Recent improvements in reflector design and particularly oven design with proper control of convected air indicate that better results than some of those reported in this article are possible. Lower source temperature infra-red resistance units such as chromalox, calrod, globar and nichrome, also have their place wherever longer wave length energy radiation is adaptable.

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Table IV—Applications for Infra-Red Baking

TYPE OF APPPLICATION	COMMENT
Prime and finishing coats on auto bodies	First successful application reduced drying time by 50 per cent. One of the early problems was the uneven drying caused by differences in thickness of body parts
Enamel on cylindrical surfaces—steering columns	Uniform thickness makes ideal application. Columns, set on spindles attached to the conveyor line, pass between banks of lights. Pulleys on spindle act against side of conveyor to rotate spindle
Baking red enamel stripe on chromium plated automobile trim stamped from 22 gage steel sheet. Chromium plate polished on one side only	Lamps were placed above conveyor but with paint side of piece up the application was unsuccessful because the high reflection factor of the polished chromium retarded the drying. When the piece was turned over so that the unpolished side received the radiation the enamel baked satisfactorily
Identification marks	Experiments are underway on drying lithographing on steel containers
Finishing odd-shaped parts	Irregular shaped parts or parts with many openings are difficult to handle economically with infra-red because so much energy is wasted. Strip heater convection ovens may be better
Metal cabinets	Metal cabinets and containers with large flat areas are particularly well-suited to this means of drying
Drying paint on machinery castings	Formerly air-dried in 24 hr. now a bank of 4 or 5 lamps dry them in one hr. Proportion of surface to volume important as too large volume of metal will conduct heat away too quickly to get good drying
Enamel on transformer cases	Change from a 4-hr. drying enamel to a 15-min. baked enamel was possible by a low-cost infra-red installation with consequent improved surface for oil and corrosion protection
Moisture drying on films, blueprints. and metal surfaces. Also in porcelain enamel work	Has been successfully used in drying film and blueprints. Water has been removed from washed metal parts in 2 to 3 min. with 250 watt lamp. Prints and films require 6 to 9 min. with same radiation. When porcelain frits are applied in water solution, infra-red lamps may be used prior to fusing process to dry the parts. In one application 105 sec. were required for a finish white and 40 sec. for a dark ground coat, evaporating 250 lb. of water per hr.
Moisture removal in large quantities	Evaporation of large amounts of water has not been entirely successful
Drying gummed flaps on envelopes	Reduced time of drying to one-tenth of time required by air-drying and with less curling of the paper
Drying latex film	Latex film sprayed on cotton or fiber batting to preserve shape of car upholstery is successfully dried. Also experimenting with proper distribution of light for curing latex cloth
Acetate glues	Used in joint of loud speaker cones, also to hold small felt patch in tip of cone. Infra-red replaced convection ovens which under unfavorable humidity conditions had a tendency to dry only the surface of the glue. Glue sizing on bond paper has been dried in half previous time
Softening plastic sheets	Infra-red lamps replaced an oven for heating plastic sheets 1/16 to 3/16 in. thick prior to punching into switch parts. Stacks of sheets in oven required high temperature to heat through which caused the top sheets to blister
Baking small transformers and motor armatures	Here large masses with small area were successfully baked in about one-third the time required by other means. In this application the tendency to conduct heat away from the surface was valuable. Small electric coils have been dried in 30 min. as compared to 2½ hr. required by an electric oven

VELOCITY-GRAPH ANALYSIS

For Solving Problems Encountered in High-Speed Motions

H. E. GOLBER
Consulting Engineer

MANY PROBLEMS in the design of high speed reciprocating machines involve the balancing of disturbing forces or the introduction of compensating forces. These can be analyzed and usually solved by constructing displacement and acceleration graphs or curves. Especially is this procedure of value in the design of printing presses and some examples taken from this field may illustrate a method of analysis that is also appropriate for other types of machines.

One interesting high speed problem concerned a printing press having a reciprocating bed, which when running, slid on the floor at every reciprocation, first one direction and then the other.

In studying the possibility of giving a new or different motion to the bed of this printing press a rather simple solution presented itself. The original motion of the bed was a forward movement at uniform speed, an harmonic reverse, a return movement at uniform speed and another equal harmonic reverse. In Fig. 1 is shown a sitegraph of the complete cycle. In the original movement *AB* was one fourth of an harmonic wave, which merged into the oblique *BC*. This is continued into the harmonic half wave *CDE*, then into the oblique *EF* and finally into the harmonic again. Note that all the harmonics are equal and that *A* to *B* and *F* to *G* is simply one harmonic.

From an examination of Fig. 1 the sites (displacements) and the driver places (times) can be clearly observed. Speeds also can be observed as slopes in the graph. Accelerations can not be readily observed in a sitegraph. So it is usual to add underneath a speedgraph (velocity graph) like Fig. 2. Note that the sitegraph portions of constant velocity *BC* and *EF* of Fig. 1 become in Fig. 2 the horizontal lines *BC*, and *EF* respectively. The harmonic parts *FAB* and *CDE* of Fig. 1 become harmonic parts *FAB* and *CDE* of Fig. 2. It is convenient to remember that a sitegraph harmonic becomes a speedgraph harmonic, but that the sitegraph harmonic crests *A* and *D* become speedgraph harmonic nodes *A* and *D* and vice versa.

Considering the speedgraph Fig. 2, note that the sites or displacements of Fig. 1 appear as areas in the speedgraph Fig. 2. The speeds or slopes of Fig. 1 appear as ordinates in Fig. 2. Fig. 2 seems to show everything that Fig. 1 does, and can be used instead.

However, the speedgraph Fig. 2 shows very clearly something that does not appear in Fig. 1. The slope of the graph in Fig. 2 shows the acceleration. Thus, since force equals mass times acceleration, Fig. 2 shows that the forces are a maximum at *A* and *D* and that they are in opposite directions. It shows that the forces at *B*, *C*, *E* and *F* are zero.

From observation of Fig. 2, it was reasoned that the tendency of the press to slide on the floor or to sway the building was greatest at the points of greatest horizontal force, that is at *A* and *D*. If the maximum force at these points would not overcome the friction on the floor, or would not crack the wall, probably no smaller force anywhere else would do so. So to cure or at least to reduce this trouble it was deemed advisable to reduce these maximum forces to give to the press bed a motion such that the slope of the speedgraph at *A* and *D* would be reduced. The questions however remained as to what kind of a graph would then be obtained, and what kind of a mechanism would it be possible to make?

It is of course possible to make changes in the mechanism without changing the speedgraph. But a change in speedgraph produces a fundamental difference, not simply a superficial one. For example, there is one machine that gives the bed a movement somewhat like Fig. 2, but differs therefrom by taking more of the cycle for the harmonic *AB*, and less for the uniform speed part *BC*. Instead of *AB* being 30 deg. it is 45 deg. The result is that the maximum slope at *A* and *D* is decreased.

Note however, that the change of AB_o from 30 to 45 deg. made a change also in B_oC_o from 120 to 90 deg. And in order that the printed area of the paper should not be made smaller, it required larger cylinders.

Another solution might be to assume

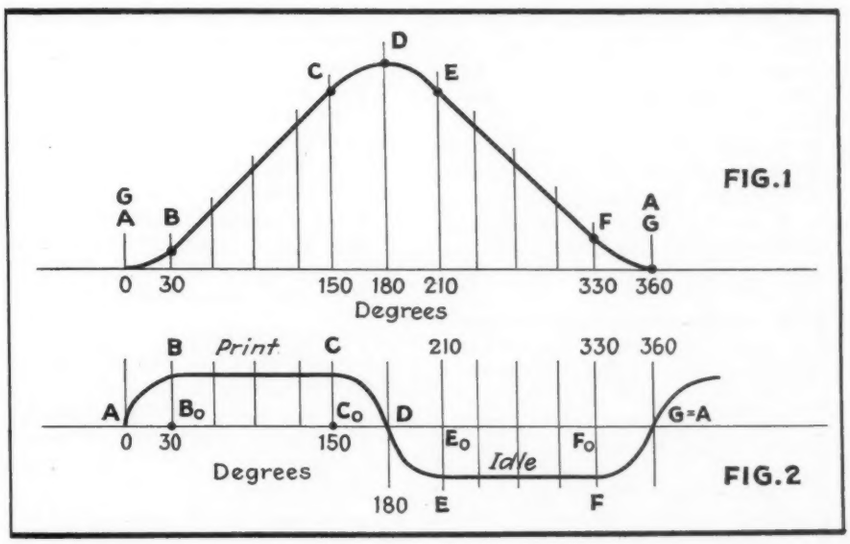


Fig. 1—Displacement curve or sitegraph of the complete cycle of the original motion of printing press bed, forward and return movements are at uniform speed, reversing speeds are harmonic. Fig. 2—Velocity curve or speedgraph derived from sitegraph Fig. 1, of printing press bed motion

that A_oB_o, B_oC_o, C_oD_o, E_oF_o, and F_oG_o in Fig. 2 must not be changed, thereby producing only minor changes that would permit keeping the machine practically as it is constructed. What can be done to improve the motion? Or rather, what can be done to decrease the high slope at A and D?

Note that if in Fig. 2 a straight line AB is drawn, then the slope is constant and is less than the slope of the harmonic at A. A mechanism producing the straight graph AB would therefore have a smaller bed force at A and it would nowhere be any larger.

Assuming that the straight line AB has been drawn to a scale such that the slope of the harmonic at A is 45 deg., then

$$\frac{B_0B}{A_0B_0} = \frac{1}{\pi/2} = \frac{2}{\pi}$$

Since inertia forces increase as the square of the machine speed, in order to obtain an equal tendency to slide on the floor, the new machine may be run $\sqrt{\pi/2}$ or 1.25 times as fast. Thus without causing more trouble, as far as sliding on the floor is concerned, a 25 per cent increase in speed can be obtained by changing from the harmonic to an oblique straight speedgraph. Notice, however, that the straight AB makes the speedgraph area under it less than the speedgraph area under the harmonic AB. That is the stroke of the bed has been shortened.

But since the bed passes under the form inking rollers, and these must never reverse on the form as they leave ink which prints as a streak, it is desirable not to decrease the stroke of the bed. If so, what then can be done?

The speedgraph harmonic can be modified as shown in Fig. 3, and the curve still give the proper area. In a quarter-wave harmonic the area under $AB = (B_oB)^2$. Moreover $AB_o/BB_o = \pi/2$. To draw AX such that the area under AXB will be equal to $(B_oB)^2$, let M be the middle point of AX. Then $AM_o = M_oX_o$ and from geometry it can be shown that $M_oB_o = B_oB$ which determines M_o, X_o and X. With this construction the area $AMXBB_o$ equals

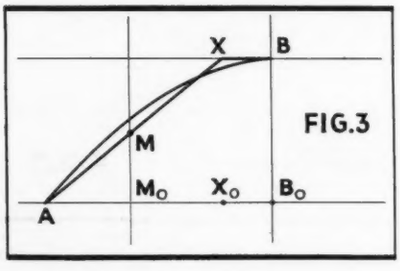


FIG.3

Fig. 3—Modified speedgraph to illustrate method of construction to obtain parabolic area equal to the harmonic area

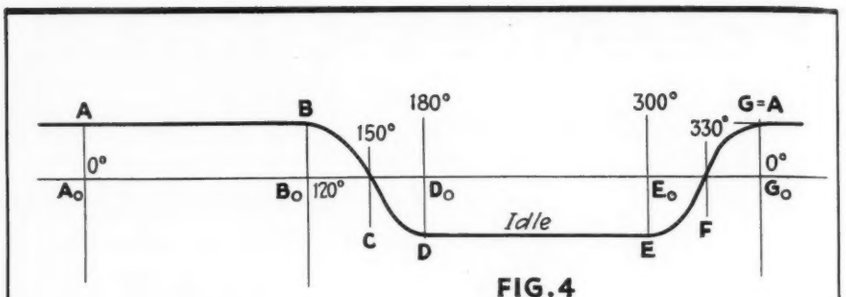


FIG.4

Fig. 4—Speedgraph representing the old complete cycle of the machine selected for improvement, with the printing and idle zones AB and DE having uniform speed

$(B_oB)^2$, or the harmonic area under AB. The bed motion stroke is then the same as before. The ink rollers will therefore clear or not clear the same as before. Moreover the new speedgraph will have the maximum slope.

$$\frac{M_0M}{A_0M_0} = \frac{B_0B/2}{A_0B_0 - B_0B} = \frac{B_0B/2}{(\pi B_0B/2) - B_0B}$$

$$= \frac{1}{\pi - 2} = \frac{1}{1.1416}$$

However this solution with a small gain of only 6 to 7 per cent was not enough to satisfy the author. True more could be gained by rebuilding the machine using larger cylinders. However another solution was attempted. Fig. 2 shows that the printing occurs from B to C of the printing stroke AD, and that then the bed returns idly from D to $(G=A)$. Could not something be done about this; why idle such a long time?

The machine selected for improvement had a speedgraph like Fig. 4. It ran smoothly up to 3,200 sheets per hr. Speeded up to 3,600 sheets per hr. the whole machine commenced to shake.

The speedgraph shown in Fig. 4 represents a complete cycle in which $G=A$, AB and DE are zones of uniform speed, that is AB and DE are horizontal, BCD and EFG are complementary halves of the same harmonic.

For simplicity assume $A_0A = 1$

Then area $A_0ABB_0 = 1 \times 120$ deg. $= 120$

area of triangle $B_0BC = \frac{1}{2} \times 1 \times 30$ deg. $= 15$

But in any harmonic quarter wave

$$\frac{\text{Area by curve}}{\text{Area of inscribed triangle}} = \frac{4}{\pi}$$

Therefore area by harmonic

$$BC = 15 \times \frac{4}{\pi} = \frac{60}{\pi}$$

Total area of the stroke

$$= 120 + 2 \times \frac{60}{\pi} = 120 \left(\frac{\pi+1}{\pi}\right)$$

In attempting to change the motion it was decided to abandon the uniform speed idle zone DE and to use all except A_oB_o to effect the reversings and return. That is, a speedgraph as shown in Fig. 5 was proposed, in which it was assumed as before that AB is the working zone, and $A_oB_o = 120$ deg. and $B_oG_o = 240$ deg. But A_oA need not be exactly 1. Of course $F=A$ since the speedgraph shows a complete cycle.

It was also assumed that BCD and DEF are straight lines, that is they give parabolic motions. And since the speedgraph represents a reciprocating body

$$\text{area } EABC = \text{area } CDE$$

$$\text{area } EABC + \text{area } BCEF = \text{area } CDE + \text{area } BCEF$$

$$\text{area } A_0AFF_0 = \text{area } BCDEF$$

$$A_0A \times 360 \text{ deg.} = 1/2\ D_1D \times BF$$

$$1/2\ D_1D \times 240 \text{ deg.}$$

$$= D_1D \times 120 \text{ deg.}$$

or $$D_1D = 3\ A_0A$$

$$D_1D_0 + D_0D = 3\ A_0A$$

$$A_0A + D_0D = 3\ A_0A$$

or $$D_0D = 3\ A_0A - A_0A = 2\ A_0A$$

From this relation it follows that C and E are located at 160 and 320 deg. respectively. Moreover

$$\text{area } B_0BC = 1/2\ A_0A \times 40 \text{ deg.}$$

$$= A_0A \times 20 \text{ deg.}$$

$$\text{area } EABC = A_0A \times [(20+120+20) \text{ deg.}]$$

$$= A_0A \times 160 \text{ deg.}$$

$$\text{and area } CDE = 1/2\ CE \times D_0D = 1/2 \times 160 \text{ deg.} \times 2\ A_0A$$

$$= A_0A \times 160 \text{ deg.}$$

so that the printing stroke and the return stroke are equal.

In order to have the complete new stroke of the bed equal to that of the old

$$A_0A \times 160 \text{ deg.} = 120 \text{ deg.} \times \left(\frac{\pi+1}{\pi}\right)$$

$$A_0A = \frac{120}{160} \times \left(\frac{\pi+1}{\pi}\right) = \frac{3}{4}\left(\frac{\pi+1}{\pi}\right)$$

$$= 0.9887$$

The complete bed stroke therefore is exactly equal in both the new and old machines. The uniform working speed is approximately equal.

In analyzing the accelerations or the slopes or grades of the graphs, it is known that, in Fig. 4 harmonic maximum grade is at the node and is $\pi/2$ times the grade of the quarter wave

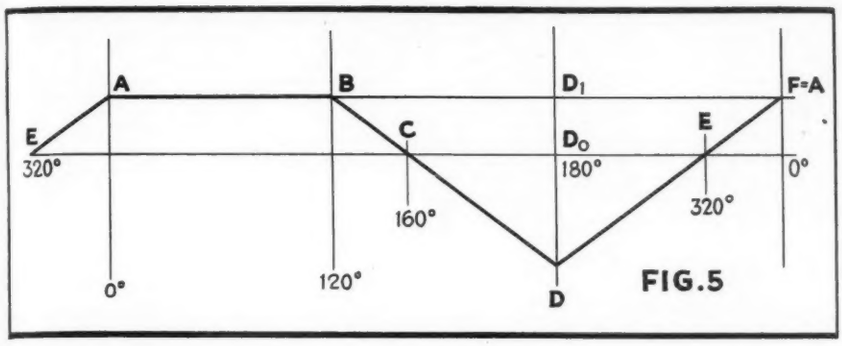


Fig. 5—Proposed modified speedgraph to replace that shown in Fig. 4 in order to increase speed but still maintain equal bed strokes

chord, or the maximum grade equals

$$\frac{\pi}{2} \times \frac{B_0B}{B_0C} = \frac{\pi}{2} \times \frac{1}{30\text{ deg.}} = \frac{\pi}{60\text{ deg}}$$

From Fig. 5 it is seen that the maximum grade is a constant grade and equals

$$\frac{B_0B}{B_0C} = \frac{A_0A}{40\text{ deg.}} = \frac{3(\pi+1)}{4\pi} \Big/ 40\text{ deg.}$$

$$= \frac{3(\pi+1)}{160\,\pi}$$

$$\frac{\text{maximum grade of harmonic (Fig. 4)}}{\text{maximum grade of parabolic (Fig. 5)}} = \left(\frac{\pi}{60\text{ deg}}\right) \div \left[\frac{3(\pi+1)}{160\,\pi\text{ deg.}}\right]$$

$$= \frac{8\pi^2}{9(\pi+1)}$$

For the condition that the two machines run at equal speeds, the maximum accelerations are as $8\pi^2$ to $9(\pi+1)$. Since the inertia forces vary as the square of the machine speed, to produce equal inertia forces the new machine can be run $\sqrt{(8\pi^2)/[9(\pi+1)]}$ or 1.45 times as fast as the old machine.

Data from the new speedgraph Fig. 5 were sufficiently attractive for the firm to build a test machine. Here the author found himself confronted by this problem: Having a speedgraph, what procedure is there to design a mechanical drive to make the follower move as the speedgraph shows?

The author then did not know of any definite procedure, so all kinds of mechanisms were examined. Finally, roll-curve gears were decided upon and the machine built. The mechanism was first tried without the bed; it ran all right. Then the bed was put on and the machine slowly speeded up. But a knock was heard at a speed of 150 sheets per hr. At 1,500 sheets per hr. the knocks were so terrific that the machine was stopped. What was wrong?

Of course, everybody immediately suspects anything that is new, consequently the speedgraph Fig. 5 fell under suspicion. It was noticed that Fig. 5 had a corner at *A*, another at *B*, and another at *D*. Fig. 4 did not have any corners. The Fig. 4 mechanism ran smoothly at least up to 3,200 sheets per hr. The Fig. 5 mechanism knocked badly at 1,500 sheets per hr. There were sudden changes of grade at *A* and *B* in Fig. 5. There were no sudden changes in Fig. 4. Obviously enough, it looked as though the change of grade caused the trouble. But a change in grade means a sudden change of acceleration, so that it was assumed at once that the trouble was caused by the sudden change of acceleration.

So it seemed, and moreover there is authority for holding this opinion. Thus in PRODUCT ENGINEERING, July, 1934, p. 252, appears the statement "shock—caused by abrupt changes of acceleration." In PRODUCT ENGINEERING, September, 1936, p. 340, it is stated "shocks—(because of) sudden changes in acceleration and deceleration." Of course both 1934 and 1936 were subsequent to the building of the machine which was in 1931. But it shows that even as late as 1936 and probably even today engineers still hold that changes in acceleration cause shocks. So did the author in 1931. But the machine was examined further. When the machine ran slowly it was noticed that the biggest knock occurred at *A*, a much smaller occurred at *B*, and there was no knock at all at *D*. On reversing the direction of rotation of the drive, the biggest knock occurred at *B*, a much smaller knock at *A*, and still no knock at all at *D*. But at *D* the change of acceleration is twice as great as that at *A*, and yet no knock. Evidently a more thorough analysis was required.

The bed was driven by a gear at the center of a 3-in. shaft crossing the machine. The drive had a gear on each end of the shaft. It was thought that the construction was good, as the distance from the end gear to the bed gear would thereby be minimized. The drive was alternately from each end gear. What caused the knock? Here the author was helped by the construction engineer who pointed out what the trouble might be. "Is it not possible that the shaft twists under the forces and so the gear teeth coming into mesh are somewhat displaced, and so upon entering hit the other teeth and cause the knock?"

After thinking it over it was decided the construction engineer was probably correct, and so the mechanism was rearranged. Both driving gears were placed compactly on one side, using a longer shaft with the bed gear near the middle as before. The mechanism was practically as before, but more compact. With this slight change in the position of the gears but with no change whatever in the speedgraph or accelerations, the machine was driven to beyond 5,000 sheets per hr. without further trouble.

As far as the author is concerned, that settled all questions about knocks being caused by changes of acceleration. He became convinced that knocks were caused by sudden contacts because of misplacements. These misplacements were caused by distortions under the forces, which may occur even when the force is constant.

This is a very important conclusion. Knocks which develop as the machine is speeded up are caused by misplacements set up by the accelerations (not the changes of acceleration). Knocks occur particularly where, while still accelerating, a new part of the drive commences to function. Knocks can be minimized by eliminating all back-lash, shortening all the bendable parts, reducing the accelerations. Knocks have nothing to do with the changes of acceleration. From this it would follow that no knock would ever occur if there were no backlash and if the drive would be continuous.

This is the author's conclusion. It differs completely from the statements previously cited. It would be worth while to have this point discussed by all those that have an opinion. Maybe in "multitude of counsellors there is wisdom."

In the engineering articles cited the term "Shock" is used. What does it mean? One dictionary says "Shock: a violent collision." "Impact: a forcible momentary contact of one body with another." What is a shock caused by? Change of acceleration, or change of velocity, or by a misplacement of the parts? Can a shock occur without making a sound?

Many machines when run beyond a certain speed are seen to produce quivers and vibration in certain parts. Are these caused by "shocks"? Where does the shock occur? Finally, should not the term "shock" be dropped until it is more clearly defined?

CHRYSLER'S NEW LABS

For Research and Engineering

OUT OF a small three-room laboratory in 1924 there came into public view a new car, Chrysler's first. People looked askance at its hydraulic brakes and high compression—features made possible only by engineering research. Today, almost every detail of a modern automobile calls for laboratory research. The importance of the work that was started in that pioneer laboratory has become so great during the past 15 years that pure science and research are now controlling factors in the success of the automotive industry.

Indicative of this, Chrysler Corporation announced the opening on June 6 of two brand new buildings housing 94 laboratories, test rooms and offices devoted entirely to development and research. The expansion almost doubles Chrysler's research facilities, and forms a sharp contrast with the corporation's three-room laboratory of 1924. It typifies the reason why the automotive industry can evolve more economical and better cars each year—and can sell more of them.

Today, a person visiting the new laboratories might see 1,500 research tests and projects in progress in the two new buildings and the older six-story building. He would see X-ray tubes being used to study the atomic structure of metals; engineers probing into experimental parts with spectroscopes to ascertain the elements of which they are composed; concentrated stresses in working parts of trucks and cars brought into full view by polarized light. He would be amazed at the intricacies of the electro-physical apparatus which produces voltages up to 500,000 volts or radio frequencies far beyond normal broadcast bands for the most exacting electrical experimentation. He would be handed a stroboscope which would let him see the vibrations set up in an automobile body, and he would watch while simple or complicated vibrations are measured by cathode tubes.

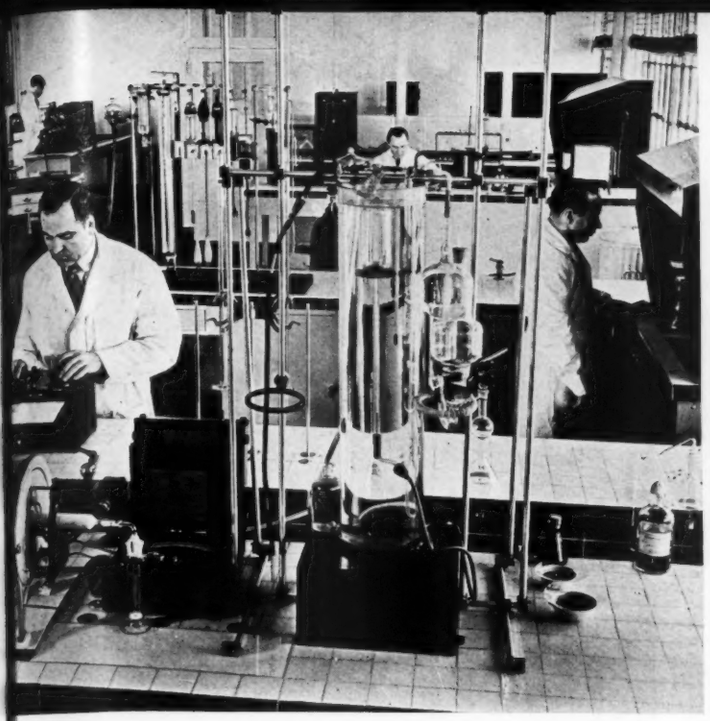
The visitor might shiver in cold rooms, perspire in hot rooms, and would visit rooms equipped to reproduce rain, salt spray and other atmospheric conditions. The dynamometer building would be of interest to him, where single cylinder, multi-cylinder, diesel and other kinds of engines are made to strain against giant dynamometers. Viewing these things, he could easily grasp the tremendous importance of the research work being carried on by the automotive industry.

Chrysler Corporation subdivides its research in three ways: there are the fundamental forward-looking projects relating to the car that may be built some day; there is the specific work on the design and materials scheduled for the forthcoming model; and there are the day-to-day problems which must be handled as they present themselves. Each project has a stated objective, a detailed budget, and a deadline for completion. Projects are extended only if they show considerable promise.

Chrysler maintains the caliber of its staff of 500 engineers at a high level through the medium of the Chrysler Institute of Engineering. Hand-picked engineering graduates are put through a two-year course in practical automotive engineering leading up to a recognized Master's degree, and on beyond to the Doctor's degree. Consequently, an unusually high percentage of the staff have two or three degrees—degrees signifying knowledge gained from the judicious mixture of practice and theory.

Interiors of the new buildings are designed to provide optimum working conditions. All walls and partitions are painted in restful beige, and floors are of red tile. Direct sunlight is diffused by venetian blinds. Laboratory workbenches are of easily cleaned black and white ceramic with non-glazed tile tops and toe spaces at their bases.

Hospital-like corridors paneled with windows permit visitors to look in upon well-lighted laboratories and the multitude of mechanical devices and scientific instruments. Color effects create an atmosphere which is restful and pleasing.



Special Ferrous Problems lab, in contrast to Routine Ferrous which checks for production, tackles special problems in alloying, heat treating, new samples. Dilatometer, top left, records expansion and contraction of metals during a change in temperature.

Mechanical laboratory has dozens of special machines which vibrate, pound, bend, twist automotive parts under varied conditions to determine mechanical characteristics. Parts get more abuse here than they ever encounter in service.

AMERICA'S MOST IMPORTANT means of defense in modern warfare is her supply of great scientific research laboratories. The Norman castles and the Scottish forts played their parts in their day, but modern defense and modern offense are mechanized and scientific, and therefore must be engineered and developed scientifically. It takes more than spirit to win today. It takes better designed machinery and more efficient weapons, both of which are the result of engineering and research. America has great laboratories in her electrical, chemical, automotive and other industries, and these are her most important weapons.

—F. M. Zeder, Vice Chairman of the Board, Chrysler Corporation.

Polarized light, a relatively new tool of the automotive engineer, is here being used to photograph stress concentrations in a connecting rod. Transparent plastic models of many parts are similarly examined to indicate design changes.

Brake dynamometer consists of motor-driven flywheel at left which can be adjusted to represent exact momentum of any vehicle. Brake is mounted at right center. In tests, time necessary to stop flywheel is recorded.

New engine experiments begin on this single-cylinder dynamometer. Single cylinder tests of experimental designs are cheaper, isolated, and fairly accurate. Multi-cylinder dynamometer test is next step. *(Continued on next page)*

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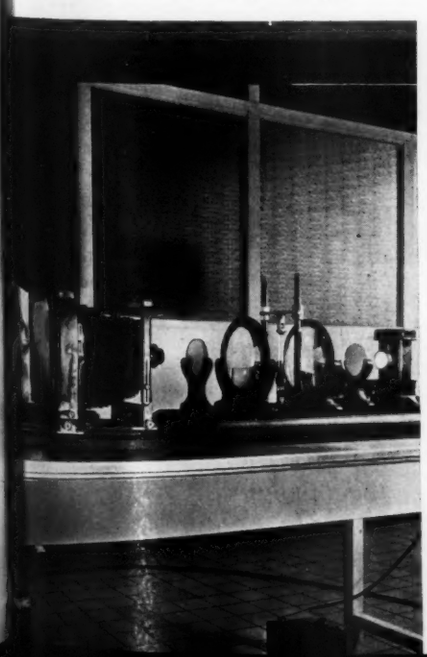
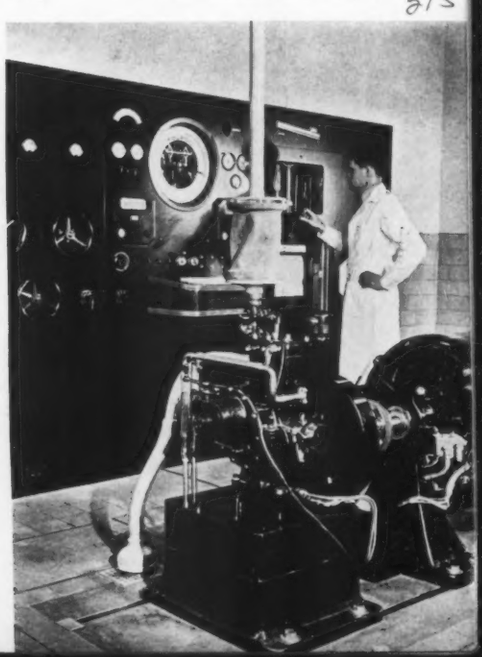




Art Department, vital to the sales appeal of a car, has walls lined with hundreds of colorful drawings of experimental models. Instrument panels and interior details are also worked up here. On blackboards skilled draftsmen render full size drawings in color to aid in final selection. Few people, no strangers, are ever permitted to enter these rooms.

Driver's visibility is scientifically charted with this set-up. Two brilliant lights mounted inside the car at the average position of the driver's two eyes cast separate shadows of posts and other obstructions on the measuring screen in front of the car. Where two shadows coincide, there is a dangerous blind spot which must be reduced to a minimum by design changes.

"Mock-up" models, in full size from clay, wood, and finally steel, are made of new body designs in this section of the Art Department. Chrysler hides their preferred models under shrouds; it is worth your life to get a good look at these jealously guarded secrets. Next step is making a real car from these "mock-ups." Thousands of tests are still necessary before the design is finally accepted and released for production.

Wind tunnel, in a corner of the well-equipped Aerodynamics Laboratory, tells engineers exactly what effect all kinds of winds will have on an automobile body. Precise models of each design are used. Alteration of a few details, such as the curve of a fender or the slope of the rear end, may so change the readings obtained that an engine of different power characteristics is indicated in order to give the desired performance.

ALLOY CASTINGS

Developments in Ferrous and Non-Ferrous Types

C. H. LORIG
Supervising Metallurgist, Battelle Memorial Institute

DURING the past quarter century the malleable iron industry has from time to time raised the general level of strength and ductility of its product, but this was done mainly by lowering the carbon content without further altering the composition or the annealing practice. The only thing that might be done to change the properties of the fully malleablized iron is to alloy it.

A few foundries are producing short-cycle malleable, the quick anneal being accomplished by taking advantage of the accelerating effect of higher silicon and by using higher annealing temperatures. This calls for careful supervision of the melting operation, a close check on raw materials, and vastly better annealing furnaces than the old box-type batch furnaces in order to reap the full benefit from the possible reduction in annealing time. These quick annealing irons have 2.0 to 2.20 per cent carbon and 1.50 to 1.60 per cent silicon, the manganese, sulphur, and phosphorus being the same as in normal malleable. The quick annealing irons can be fully malleablized in less than 24 hours in continuous furnaces with temperatures close to 1,800 deg. F. in the first stage of malleablization.

Various so-called pearlitic malleable irons which range in tensile strength from 60,000 to 120,000 lb. per sq. in. are being marketed. New combinations of properties are to be found in these irons.

Much interest has been shown in the low carbon irons, or steels as they are often called, of the Ford crankshaft type which, in a sense, belong to the malleable class. These are highly alloyed and are given a short heat-treatment to graphitize part of the carbon and to impart some ductility.

From an alloy standpoint, the development of various types of silicon bronzes has been of major importance in the past few years. Several bronzes in this class have made considerable progress in the last year in the engineering field, notably those of the Everdur type and P.M.G. metal. The latter also contains, besides 1.2 to 3.2 per cent silicon, 0.5 to 1.2 per cent iron. Some silicon bronzes have been modified to permit heat-treatment.

Silicon has a marked effect on increasing the fluidity of bronzes. While silicon bronzes have had a rather bad reputation with the foundrymen, owing to their tendency towards gas porosity some of the modified silicon bronzes seem less susceptible to this difficulty. One silicon alloy developed at Battelle is of the latter type. It has 83 per cent copper, 5 per cent silicon, 10 per cent zinc, 1 per cent manganese, 1 per cent aluminum, and has a tensile strength of 88,000 to 92,000 lb. per sq. in., a yield of 46,000 to 60,000 lb. per sq. in., and an elongation of 1 to 4 per cent.

In working with this alloy it was found that the most practical means of eliminating the absorbed hydrogen and of making sound castings has been to overheat the melt temporarily, to about 2,000 deg. F., whereby zinc vapor sweeps out most of the gas. After about a minute of this treatment the melt is quickly cooled to the pouring temperature of about 1,650 deg. F. and cast. This alloy is susceptible to precipitation hardening. It is quenched from 1,425 to 1,470 deg. F. and subsequently heated to 575 deg. F. at which temperature it precipitation hardens rapidly, giving a maximum hardness in about 15 minutes.

In studies at Battelle on the question of unsoundness of the copper-silicon zinc brasses melted in various gases, it was found that hydrogen caused marked unsoundness regardless of the crucible material or the dryness of the hydrogen. While the results on steam were not conclusive, it appeared as if steam had little to do with unsoundness. We were unable to attribute unsoundness to carbon monoxide. Superheating of this alloy caused the zinc vapors from the alloy to sweep out most of the gas.

One outstanding development in copper alloy production has been the use of antimony, arsenic, or phosphorus to prevent dezincification in admiralty and other condenser tube alloys subject to such attack. While the trend in wrought copper production is strongly toward these modified alloys it is doubtful that the non-ferrous casting industry has as yet utilized antimony, arsenic, or phosphorus to prevent dezincification in copper-zinc castings subject to such attack. The amount of antimony or arsenic used is 0.1 to 0.2 per cent.

Heat-treatment of non-ferrous alloys is becoming more and more common. The modification of some silicon bronzes and brasses to permit heat-treatment has been mentioned. Beryllium bronze always depends upon heat-treatment for best results, and aluminum bronzes, which have been heat-treated for some time, are now being used in heat-treated form to a greater extent. The copper-chromium alloys are often in the precipitation hardened state.

In reviewing electrolytic manganese and its alloys, Dean states (*Metal Progress*, Vol. 36, 1939, pages 357–358) that alloys containing 65 to 70 per cent zinc, 20 per cent manganese and the balance copper, give excellent high-strength castings and should be attractive because of their cheapness. A manganese base alloy with 80 to 85 per cent manganese and 15 to 20 per cent copper on quenching from a solution temperature has a low hardness of 50 Brinell. In a subsequent precipitation hardening treatment it reaches a hardness of 500 Brinnell. Since 1934 the production of magnesium castings has increased several fold. The magnesium alloys are also strengthened and made more ductile by heat-treatment.

Powder metallurgy is slowly challenging the casting industry. Investigations are being conducted in the possibilities of substituting the processes used in powder metallurgy for the production of articles now made by standard practices of melting, casting, and fabricating. Powder metallurgy is proving useful in some phases of bearing manufacture. Oil-less bushings with uniform porosity are widely used.

In conclusion, the casting industry has conducted endless experimentation of a practical nature. There has been, however, an almost complete absence of fundamental research. The production of good castings represents, as Melmoth stated, (*Foundry*, Vol. 48, July–Aug. 1939) a combination of practical and theoretical factors involving great difficulty in their elucidation and understanding.

PNEUMATIC CIRCUITS—II

For Controlling and Operating Machine Cycles

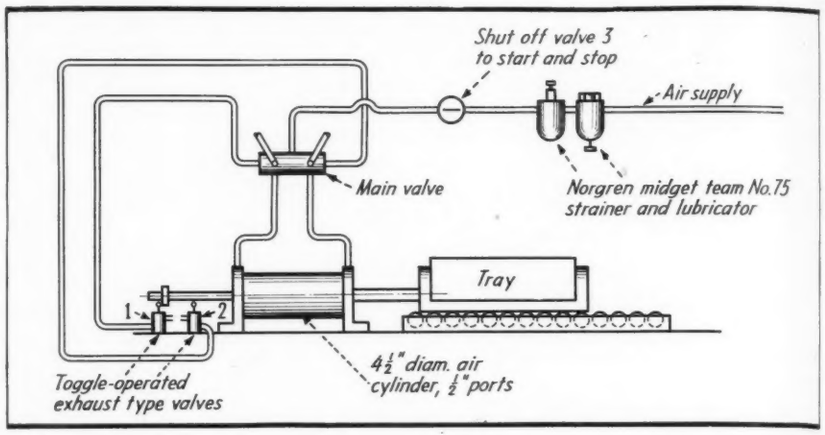
L. A. WARD
Consulting Engineer, Tomkins-Johnson Company

PNEUMATIC control valves are designed in many styles so that they can be readily attached or mounted on flat or projecting surfaces of machine frames. Standard valve types are arranged for either foot or bracket mounting, and with pipe connections on either the right or left-hand side to facilitate piping.

When selecting a place to mount the control valve, some forethought should be exercised to make sure the barrel or housing of the valve or control will not be strained or twisted out of alignment when a load is imposed on the machine, thus cramping or binding the working parts of the valve so that their easy operation is prevented.

Piston rods may extend beyond one or both ends of work cylinders. The rod ends may have either external threads or be drilled and tapped with internal threads to suit the method of attachment to machine parts.

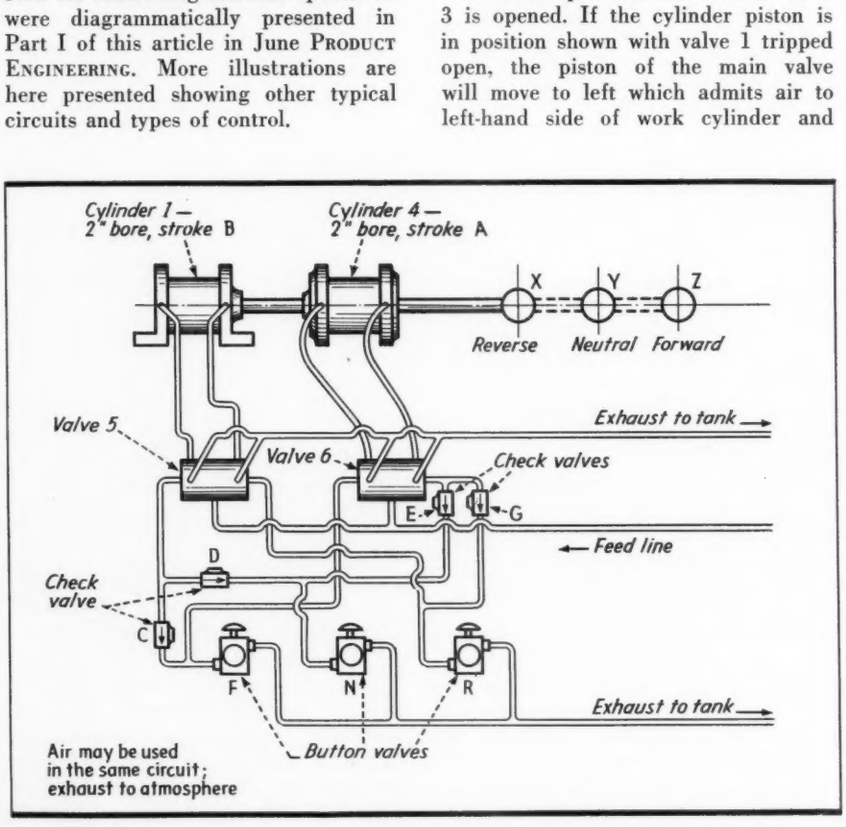
A few arrangements of pneumatic circuits for controlling machine operations were diagrammatically presented in Part I of this article in June PRODUCT ENGINEERING. More illustrations are here presented showing other typical circuits and types of control.



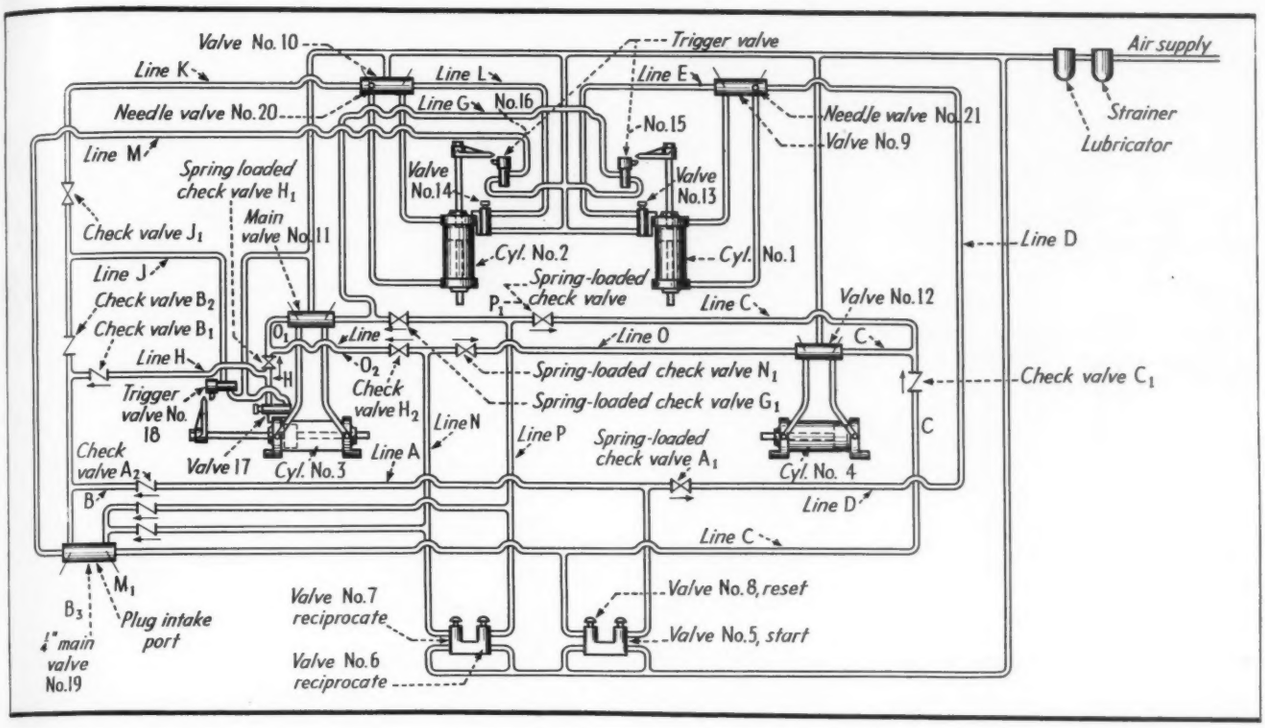
Tray shaking arrangement. This hook-up is a simple self-reversing control in which the collar on the piston rod extension trips the toggle operated exhaust valves 1 and 2, and causes a continuous reciprocation of the piston rod.

To start operation the shut-off valve 3 is opened. If the cylinder piston is in position shown with valve 1 tripped open, the piston of the main valve will move to left which admits air to left-hand side of work cylinder and exhausts air from right-hand side of work cylinder so that work piston moves to right until the collar on piston rod strikes toggle on valve 2.

When valve 2 is opened by collar striking the toggle, air is exhausted from right-hand side of main valve and main valve piston moves to right thus admitting air to right-hand side of work cylinder and exhausting air from left-hand side of work cylinder thus moving work piston to left until collar strikes toggle on valve 1 to complete cycle.



Marine drive gear shift using hydraulic system. Cylinder 4 is mounted on end of fixed cylinder 1 piston rod. both move together. To shift into forward, valve *F* is depressed to exhaust oil from left-hand end of valve 5, feeding oil to blank end of cylinder 1, moving shift to neutral, simultaneously oil is exhausted from left-hand end of main valve 6, feeding oil to blank end of cylinder 4 thus extending *X* to point *Z*. To move to *X*, valve *R* is pressed to exhaust right-hand ends of valves 5 and 6 through check valve *G*. Check valve *E* stops flow to check valve *D* and valve *N*. Valves 5 and 6 move to right-hand ends feeding oil to rod ends of cylinders 1 and 4, bringing shift back to point *X*. Depressing button *N* exhausts oil from left-hand end of valve 5 and right-hand end of 6 through valve *E*, moving piston in cylinder 1 to right and piston in cylinder 4 to left bringing shift to *Y* or neutral. If air is used in this circuit exhaust is to atmosphere.



Pressure control circuit for clinching machine, this circuit employs a small size main valve in the control circuit. Starting with the cylinders 1 and 2 in the up position, with 3 to the left and 4 to the right, valve 5 is depressed to start cycle. This admits air pressure to line *A*. Check valve A_1 being spring loaded, and check valve A_2 not being loaded, air is permitted to move through to line *B*. Check valves B_1 and B_2 are opposite flow so that air flows to valve 19, which is a ¼ in. main valve in the control circuit for switching the control from valve 7 and 6 to valves 8 and 5.

Tracing the circuit from valve 19, if the reset valve 8 was not pressed before valve 5 was operated, so that the control is still under valves 7 and 6, air is exhausted freely through valve 19 to the atmosphere at B_3. When the reset valve 8 is pressed, air flows to line *C* moving valve 19 to the left, closing port B_3 and connecting pipe line *B* to the port that is plugged, so that line *B* is then cut off. Valve 12 is also moved to the left end by air passing through the check valve C_1 placing cylinder 4 in the position shown in the diagram.

Tracing the circuit from line *A*, with the line *B* closed off at valve 19, pressure will build up in line *A* until it will pass through the check valve A_1 to line *D*. This moves valve piston 9 to the left, feeding air to the top end of cylinder 1, a speed control needle valve is placed in the exhaust port of the valve 9 to control the down speed of the cylinder. As the cylinder reaches the bottom of stroke, the arm on the upper rod opens valve 13, feeding air to the left-hand end of the main valve 9, through pipe line *E*, which causes the cylinder 1 to move upward.

As the cylinder moves and is close to its top position, the finger on the upper rod trips trigger valve 15 feeding air to line *G*. Check valve G_1 is closed in this direction so air passes only to the right-hand end of main valve 11, moving piston to the left, feeding air to the left end of cylinder 3, causing it to move to the right. On completing its stroke valve 17 is opened feeding air to line *H*, air will pass through check valve B_1 to line *B* and check valve B_3 on valve 19 is closed so that the pressure will increase and pass through the spring loaded check valve H_1, and as H_2 is opposite in flow, air passes on to main valve 11 at the left-hand and moving its piston to the right, causing cylinder 3 to reverse and move back to the left end. Near the end of the stroke of cylinder 3, trigger valve 18 is opened feeding air to line *J* with line *B* blocked, as described previously, air will not pass through check B_2 but will pass through check valve J_1 to line *K* and to the left-hand end of main valve 10, moving its piston to the right and feeding air to the right-hand port thus to the top end of cylinder 2. This cylinder then moves down, controlled by the needle valve 20 in the left-hand exhaust port.

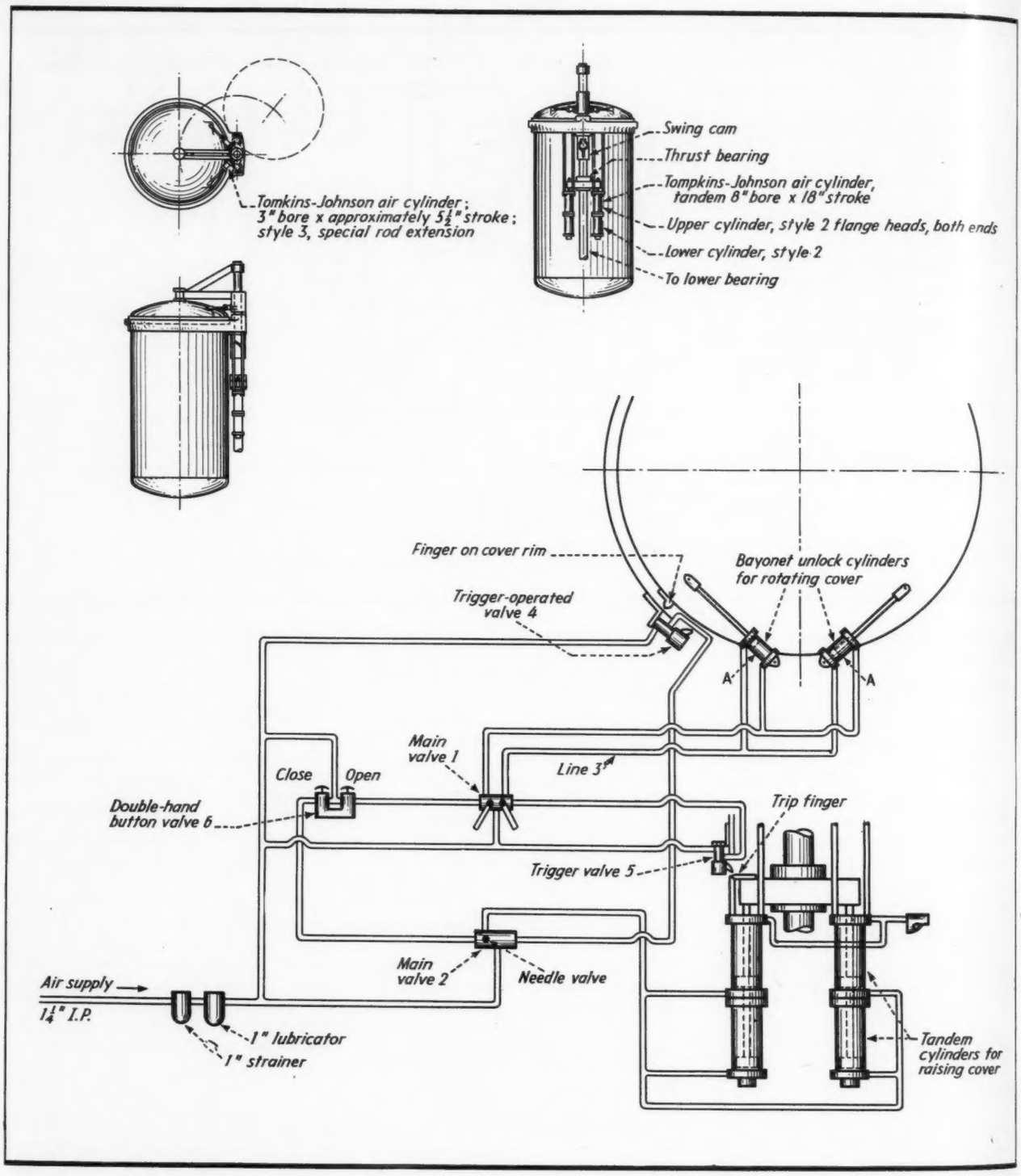
When cylinder 2 reaches the bottom of its stroke valve 14 is opened so that air is fed to line *L*, reversing valve 10, which reverses the left-hand working cylinder 2, bringing it to top position.

Near the top stroke of cylinder 2, trigger valve 16 is opened and air is fed to line *M*, leading to the left-hand end of main valve 19, this moves the piston to the right-hand end opening port B_3 making hand valve 5 inoperative and valves 7 and 6 operative by closing port M_1.

By opening the valve 7, air passes to the line *N* and through check valve H_2 to line O_2 to the left end of valve 11, tending to move the piston to the right-hand end, but since this is the position in which the piston is resting at this time nothing happens further. Air also passes through spring loaded check valve N_1 to line *O* to the left-hand end of valve 12, moving the piston to the right-hand end and feeding air to the right-hand end of cylinder 4 moving its piston to the left.

As the valve 6 is depressed air is admitted to the line *P* passing through the spring loaded check valves G_1 and P_1 to line *G* and line *C* causing the valves 11 and 12 both to reverse, this causes both cylinders 3 and 4 to move to the right and when the valve 7 is operated, the cylinders are reversed again to the left.

When the number of reciprocations necessary to clinch the work properly have been completed, and unloading is desired, the reset valve 8 is operated, moving the cylinder 4 to the right-hand position where unloading and loading operations are accomplished. Valve 5 can then be depressed and the next cycle started. *(Continued on next page)*



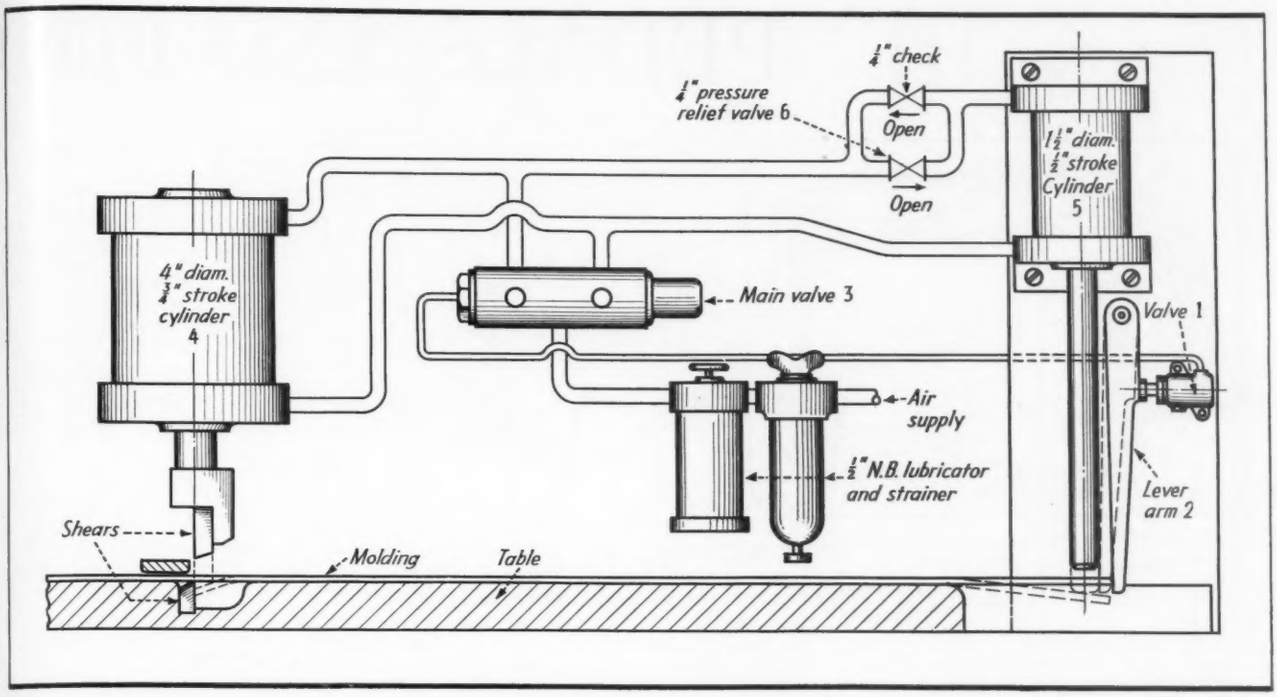
Kettle cover lifter. Pneumatic cylinders applied to a 9 ft. diam. vulcanizing kettle, for unlocking, raising, and swinging to one side a 5,000 lb. cover. The cover is clamped down by a bayonet lock.

Mechanism operates using pressure control. By depressing the right-hand button of double-hand button valve 6 air is admitted to the left-hand end of main valve 1, moving the piston to the right-hand end, delivering air to line 3, thus to the two bayonet unlock cylinders *A* causing them to rotate the cover. When this is done, a finger on rim of the cover contacts the trigger operated valve 4, causing it to admit air to the right-hand end of main valve 2. This moves the piston to the left-hand end, feeding air to the lower part of the two tandem cylinders to raise the cover.

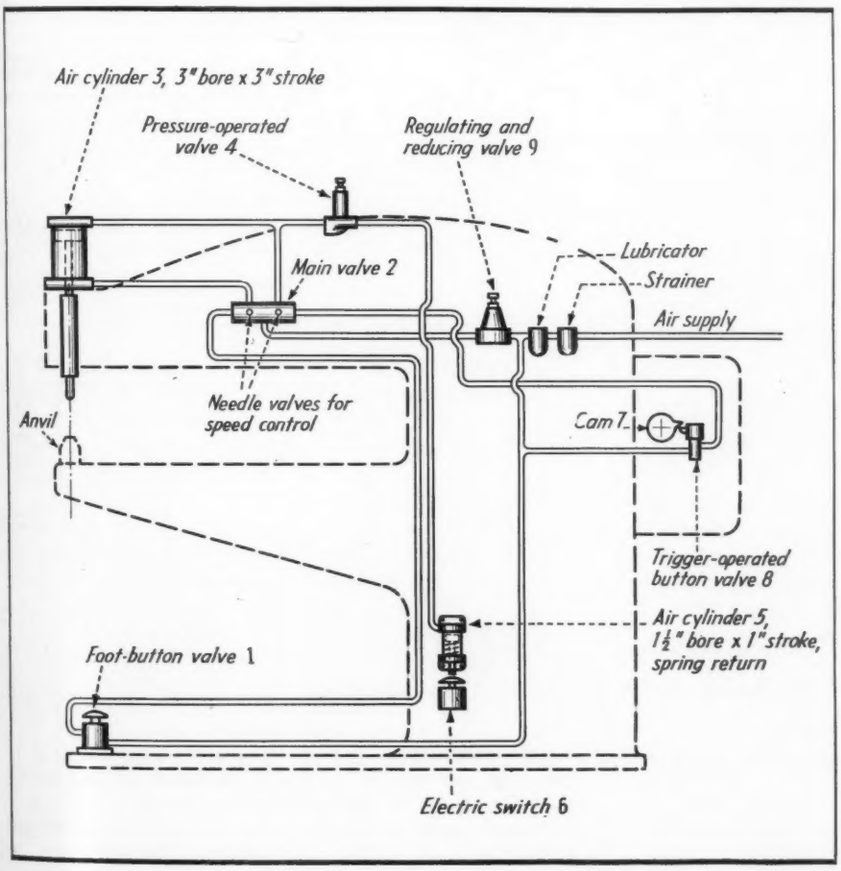
When cover has been lifted enough to clear the top of kettle, a cam action takes place that causes the cover to swing to one side.

To close kettle the left-hand button of valve 6 is depressed, feeding air to the left-hand end of main valve 2, exhausting air from the tandem cylinders to let the cover swing back over the kettle as the cover lowers to place.

When the cover is almost closed, a second trigger valve 5 is actuated reversing main valve 1 causing cylinders *A* to rotate cover into bayonet lock.



Pneumatic arrangement for cutting off molding as it is delivered by a continuous forming roll. Molding after being formed moves along the table and contacts the lever arm 2 swinging it back, causing the valve 1 to be opened exhausting the air from the left-hand end of the main valve 3. This moves the piston of the valve 3 to the left, feeding air to the left-hand port, thus to the top of the 4 in. diam. cut-off cylinder 4. Cylinder 5 is retarded in its action by the pressure relief valve 6 which maintains sufficient back pressure against the line to cause the cylinder 4 to cut off the stock. Air then flows into the cylinder 5, pushing the stock off the lever 2 allowing valve 1 to close whereupon the main valve 3 reverses, returning both the shear and the push-off cylinders 4 and 5 to their top positions.



Air circuit for welding machine. After the work has been placed on the anvil, the machine cycle is started by depressing the foot button valve 1 thus admitting air pressure to the left-hand side of the main valve 2 moving its piston to right side, thus delivering air to the top side of cylinder 3 and exhausting the bottom side of cylinder 3, and moving piston of cylinder 3 down to contact work on anvil. When pressure is built up in cylinder 3, the pressure operated spring loaded check valve 4 opens delivering air to and operating cylinder 5 which closes the electric switch 6, this closes the electric circuit for applying the welding current.

After the welding machine goes through its cycle of operation, the cam 7 trips the trigger on the button valve 8 admitting air pressure to the right-hand side of main valve 2 and moving its piston to left-hand side, thus delivering air to the bottom of cylinder 3 and simultaneously exhausting the air from the top of cylinder 3, at the same time the pressure is removed from the spring return cylinder 5 thus opening the electric switch 6. The welding pressure on the work can be controlled by adjusting and setting the valve 9, this valve is of the pressure regulating and pressure reducing type.

PEDALS AND FOOT

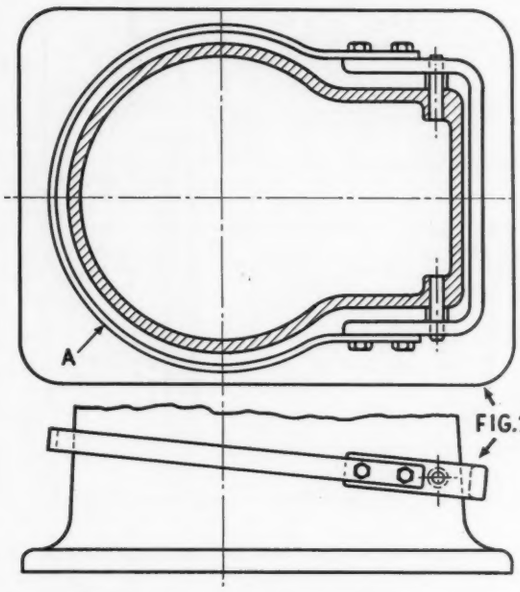


Fig. 23—Strap iron treadle *A*, bent to conform to shape of machine base, permits operation from any station. Floor plate can be welded to strap to give larger foothold if desired.

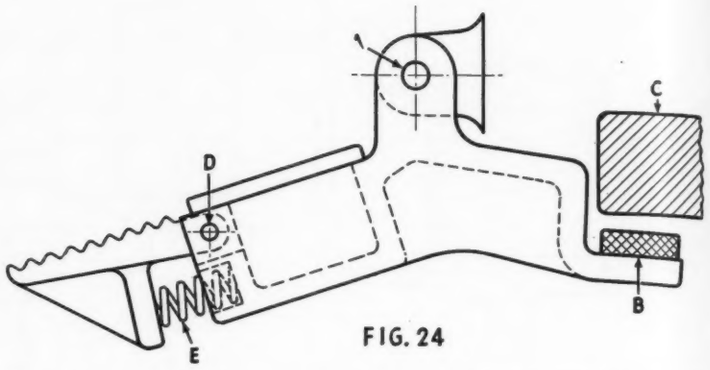
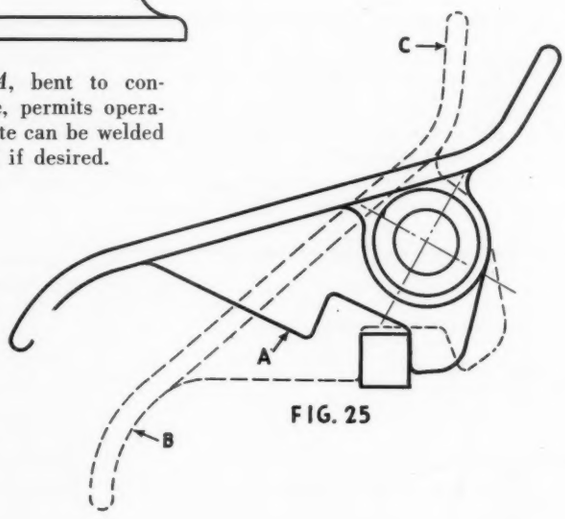


Fig. 24—Combination electrical switch and brake pedal shuts off power when treadle is rotated about *D*, and simultaneously brings braking pad *B* into contact with rotating member *C*. Treadle returns to original position by spring *E*.

Fig. 25 — This treadle, with the operator in a sitting position, is shaped so that the toe can be used either to pull the lever up at *B* or to push down at *C* when the lever is in the position shown by dotted lines. Reinforcing web *A* is notched to engage cast stop.



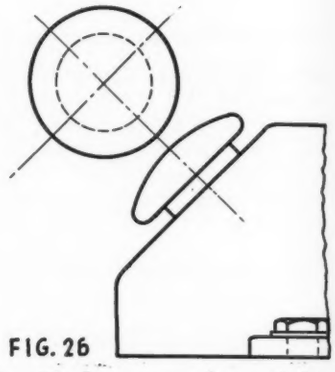


Fig. 26—Large round-topped button, positioned 45 deg. to the floor to allow the operator to rock his foot from the heel, is limited in travel by the switch case. The case is built wide to provide a foot rest.

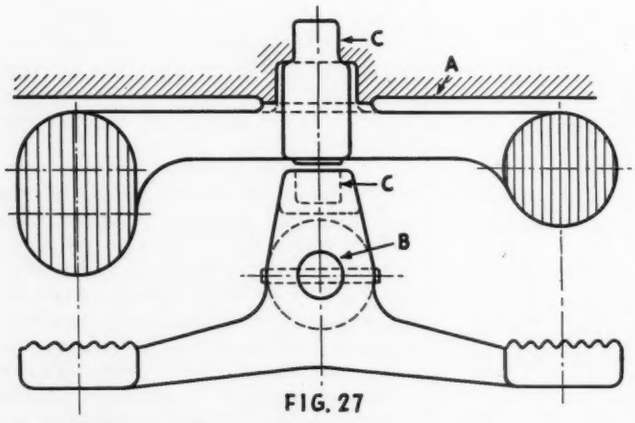


Fig. 27—Double-acting treadle is mounted on the outside of a case which houses the electric starting switch. Electrical contacts operate through shaft *B*. Stop *C*, rugged enough to withstand heavy pressure, limits travel in both directions. Treadle returns to neutral position when pressure is released.

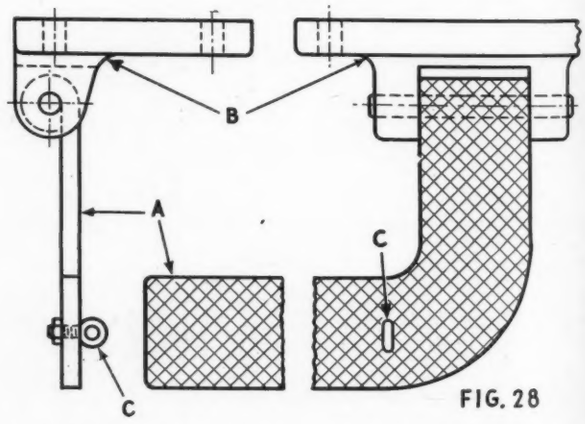


Fig. 28—Right angle treadle *A* is made of non-skid floor plate, one end of which is bent round and reamed out to form the pivot. Treadle pivots on a pin in the cast bracket *B* which is bolted to the machine base. Screw eye at *C* is wired to the tripping mechanism.

OPERATED LEVERS—III

FRED ADAMS

FOOT-controlled members are, in most instances, automatically returned to their original or neutral positions. Various mediums of return are used, but the spring seems to be the universal favorite, helical types, torsional, and leaf springs being most common. Counterweights, both fixed and adjustable, are prevalent where gravity can be utilized. Other installations are operated hydraulically or pneumatically. Limiting stops for treadles are often necessary, particularly on electrical machines where foot-operated switches must be protected from rough kicking.

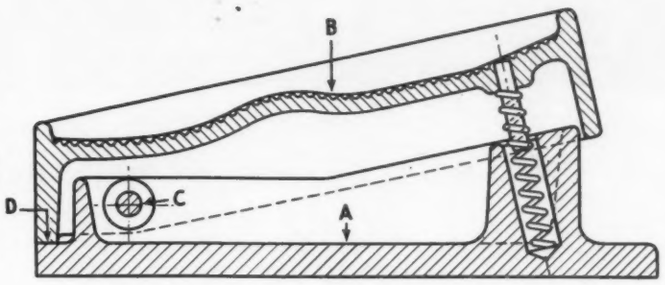


FIG. 29

Fig. 29—Cover *B*, pivoted at *C* and flanged and shaped to fit sole and heel of the operator's shoe, operates electrical switch contained in cast iron floor box *A*. Coiled spring returns treadle to neutral; stop *D* limits upward movement.

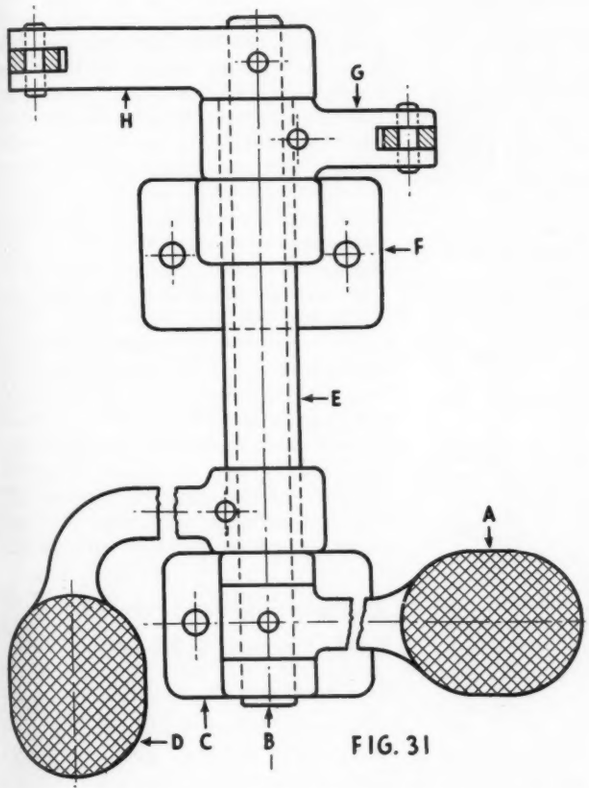


FIG. 31

Fig. 31—Two front levers *A* and *D* are mounted on solid and hollow concentric shafts. Shafts are supported by floor brackets *C* and *F*. Connections to the tripping mechanism are fastened to levers *G* and *H*.

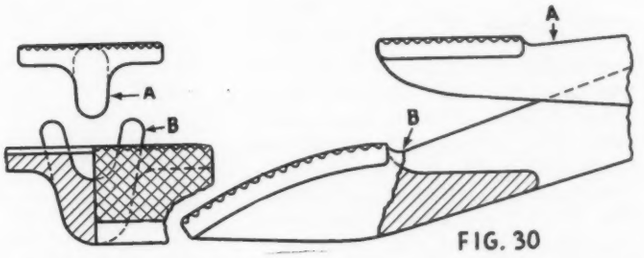


FIG. 30

Fig. 30—Nested designs such as this can be used where space is limited, or where levers must be close together.

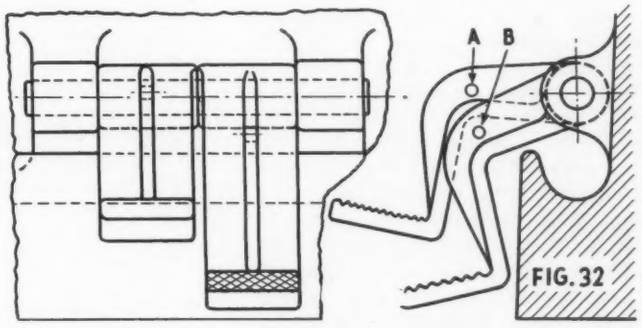


FIG. 32

Fig. 32—Identical foot levers are designed to project over oil-catching flange on machine base. Tripping mechanism, fastened at *A* and *B*, raises one pedal as other is depressed.

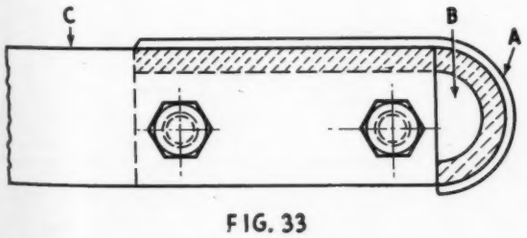


FIG. 33

Fig. 33—For greater safety, floor plating is bent half-around at *A* so that as the foot approaches the treadle, the sole of the shoe can strike at an angle and still be guided onto the top surface.

Fig. 34—Treadle *A* of this combination cast iron and sheet metal pedal is bent around a pin to form bearing. Web of cast base *B* is short of pin center at *D* to place the fulcrum near floor.

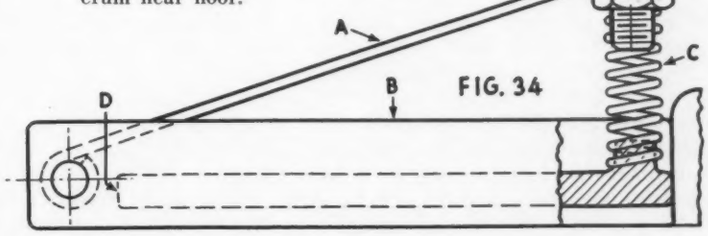


FIG. 34

Question and Comment

Discussion of Cam Design Analysis

H. E. GOLBER
Chicago, Ill.

The article "Cam Design Analysis" by W. H. Shorter, Jr., published in the May, 1940 number of PRODUCT ENGINEERING contains quite a number of interesting points. The writer disagrees with Mr. Shorter in some of his conclusions.

The formula $W_w = \frac{CF}{1/R_1 + 1/R_2}$ may be interpreted thus: The safe wear load depends on the material, on the width of face, and on the total relative curvature. Is thus true? Into all ball bearing formulas, the speed enters. Why does it not enter into this formula? The writer hopes the formula is true as it is very simple, but reference to publications showing its derivation and corroborative tests will be appreciated.

There seems to have been some difficulty encountered with the machining of the "leader" or master cam. In one establishment master cams are made by rectangular coordinates on a Pratt and Whitney jig-borer and no difficulties are encountered. The spindle of the jig-borer is located where the roller center should be, and a cutter of proper radius cuts away the stock leaving the cam shape with little ridges between. These ridges are removed later by hand leaving a perfectly smooth cam surface. Moreover, it does not "destroy the theoretical accuracy of the track," because when finally finished the original cutter marks are still visible. The cam is easily made correct to 0.0005 in.

It is suggested that the radius of curvature

$$\frac{\left[R^2 + \left(\frac{dR}{d\alpha}\right)^2\right]^{3/2}}{R^2 - R\left(\frac{d^2R}{d\alpha^2}\right) + 2\left(\frac{dR}{d\alpha}\right)^2}$$

be figured at equally spaced angular positions. The writer has used this formula for many years, finding it first in "Carr's Synopsis of Mathematics." It was found that the labor involved was very great and all wasted. The cam had to be drawn anyhow, and that gave the curvature closely enough.

On page 224, third column it says, "the data obtained for the swinging type followers are mathematically correct, a condition which is only approximated by a graphical construction." The writer is puzzled, since he could find nothing in the article to connect therewith. The writer frequently computes cams for swinging followers by the use of sines and cosines. He would like to learn more about the application "of the data to swinging followers" as it is a subject he labors on constantly.

There are four graphs submitted, the harmonic, the gravity, the cycloidal and the cube and gravity combination. The last two are recommended for "characteristics which are favorable to high speed motions starting under load." The first two graphs are discarded. The writer wonders why?

The harmonic graph has characteristics which make it the best graph for certain conditions. The writer computed that its characteristics permitted one machine to run 30 per cent faster than otherwise. In addition the gravity graph also has certain characteristics, which under certain conditions make its use desirable. The cycloidal and combination graphs have been discussed before. The cycloidal graph is discussed in "Kinematics of Machinery" by Albert and Rogers 1931, pages 147-149. The Cube-curve is discussed in "Cams" by F. D. Furman, 1921, pages 1254-131.

But why was it decided that the combination and cycloidal graphs had "Characteristics favorable to high speed starting under load." Apparently because the acceleration starts with zero, and ends with zero. What is gained thereby?

There has been a controversy on this subject, in the pages of PRODUCT ENGINEERING during the preceding years. As the writer sees it, a body starting to fall under gravity starts smoothly enough, and in rising against gravity stops smoothly enough. In the previous controversy the discussion was shut off unfinished. I hope this will not happen here.

Here again "under certain conditions" not mentioned in the article, the cycloidal and combination graphs are better than either the harmonic or the gravity. But these conditions do not always occur and can be avoided, and then the cycloidal and combination graphs are definitely worse. Attention is directed to the maximum acceleration, which is least for gravity, and higher for all the others.

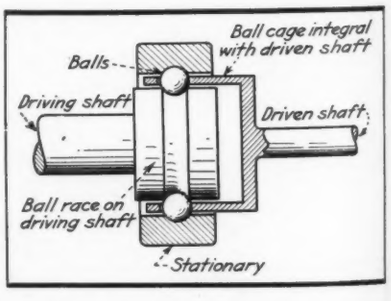
It would be very desirable, if the basis for any conclusions that are reached should be specifically stated so they may be examined. These may be based on theoretical considerations such as the assumed desirability of zero acceleration at start, or may be based on practical experience. If the latter, the experience should be given in detail so it might be judged whether a false analysis is not being made.

The writer of this letter himself has sinned often enough by making a false analysis. He has frequently blamed on the cam design many troubles for which it was not responsible. This he proved by afterwards curing the trouble without changing the cam design. It would be highly informative if engineers would give case histories of various troubles encountered and how they were cured.

Answers Question On Ball Speed Reducer

To the Editor:

Referring to page 232 of PRODUCT ENGINEERING for May, M.J.N. of California wants some information concerning a ball speed reduction unit. The unit illustrated was the invention of C. G. Garrard, who licensed the Crocker-Wheeler Electric Manufacturing Company, Ampere, N. J., to build speed changers under his patents.



This type of reducer was discon-

tinued because of mechanical difficulties. It could only be used for very light loads and the pressure between the balls and races must be very heavy.

—H. M. EDMUNDS
Ampere, N. J.

Ball Speed Reducers Built as Specials

To the Editor:

In your May number, under initials M.J.M., is a request for information concerning a ball bearing used as a reduction gear. I can present considerable history on this.

The first units of this type were built with a two-row bearing using a small difference in pitch diameter to offer an extremely large reduction in a single step with very small power. They were used for driving the rotating air distributor on fans mounted in the ceiling of pullman cars. This was back in 1922 and 1923.

A number of the single row type, such as your correspondent describes, are now being used as a fixed ratio reduction gear for a two-speed arrangement on record drivers for broadcasting station reproducing phonographs.

We built some samples of the two row type for a large reduction for a proposed controllable propeller drive, and we also built some samples of a single row type for a step-up gear on high speed grinding spindles. We have specific details as to its possibilities, because there are definite limitations to this reduction gear. So far as I know, these units were all built as specials by some of the regular ball bearing manufacturers.

—THOMAS BARISH
Marlin-Rockwell Corporation

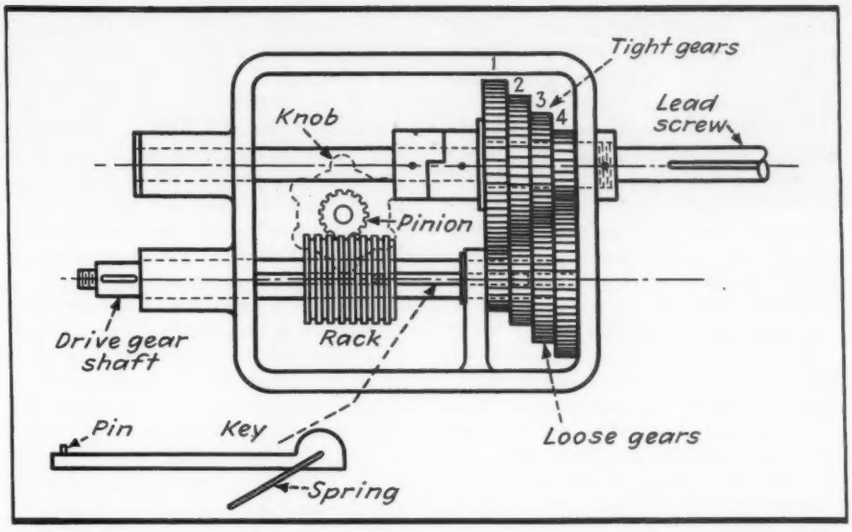
Flywheel Substitute?

To the Editor:

We are developing a compact, lightweight, portable machine in which an electric motor drives a turntable. It is absolutely essential for the fine performance of the machine that the turntable have a constant angular velocity free from all sudden fluctuations.

A massive flywheel has proved satisfactory in stationary equipment, but is undesirable in portable machines because of its weight. We are looking for some means of obtaining the flywheel effect without the flywheel, and would greatly appreciate any suggestions or ideas from your readers through "Question and Comment."

—SAMUEL WESERT
New York, N. Y.



Circular Rack With Single Pinion

To the Editor:

In reply to a query by Mr. Wm. T. Savage, Jr., on page 277 of the June 1940 number of PRODUCT ENGINEERING, we have been using a circular rack with a single pinion to select speeds of feed on our roll turning lathe, used in turning copper rolls for textile use. The sketch shows the interior of the gear box.

As you will notice, there are four sets of gears constantly in mesh. Drive gear shaft is slotted to admit key, which is moved by turning knob on outside of gear case, thus sliding rack and key to desired position. A spacing washer is placed between each of the loose gears, depressing the key so two gears cannot be connected simultaneously. Loose gears are notched on bore to receive ear on key.

—FRANK L. EATON
Johnson & Bassett, Inc.

Industrial Designers Discuss Cabinet Design

To the Editor:

Much to our chagrin, Mr. N. V. Smith, President of the Smith-Johnson Corporation, calls us "art designers," and apparently assumes that we are in the business of waving our hands, tearing our hair, and raising the devil in general with "bad art." (PRODUCT ENGINEERING, June, page 276.)

I have prepared some necessarily brief and reserved comments on Mr. Smith's cabinets. I do not attempt to suggest changes in their design, but will criticize them in their present shape. These comments, of course, will apply to the photograph of the machines as it appeared last month.

First, we will take the over-all shape. The present shape of the cabinets is not at all bad, but it has been used by so many other manufacturers of the same type of unit that this may be one reason why they don't look right to Mr. Smith. Some attempt should have been made to obtain a shape, although functional, somewhat different from that of the average cabinet of this type.

There is a tendency for the cabinets to look a bit top-heavy, because of the conglomeration of tubes and faucets at the top. Effort should be made to make the center of gravity at least appear to be very low. Leave off any unnecessary trim parts at the top, and make the trim at the bottom quite heavy and solid looking. Perhaps use a slightly deeper base, which could be inset and painted black as at present. Parts on the top of the cabinet should if possible be finished in a light color.

One line under the name would be much better than three. Inasmuch as it would be best to make the cabinet appear as low as possible it would be best to stick to horizontal lines and eliminate vertical trim.

In this type of equipment, color combinations are quite a problem. We have had the occasion, when restyling a product that called for a baked enamel finish, to call in outsiders whose unbiased opinion in the matter of color was needed. Almost without fail, when an item was to be used where surrounding colors might be in almost any combination, we had to resort to white with black trim. This applies mainly to home appliances where only one color combination could be offered by the manufacturer. I presume this is the case with Mr. Smith. In his case,

however, I would suggest a color just a little more on the warm side, or a base color such as buff or desert tan. White shows grease too plainly.

For trim color I believe another warm color should be used, such as a deep maroon or dark brown. There should be some bright spot of color somewhere on the cabinets, probably best carried out in the name plate. This should be either a very bright red or a brilliant blue.

I hope these comments will be taken with a grain of salt, as they were made after looking only at a simple photograph. Some of them might have to be retracted were I to view the cabinets in the flesh.—KARL BROCKEN, *Associate Brooks Stevens, Industrial Design*

To the Editor:

The trouble with the grease pump cabinets presented by Mr. N. V. Smith in the June number lies in the striking contrast and lack of harmony between the sheet metal housings and the pump fittings which are not concealed within the housings, but which are, in fact, prominently displayed.

If prominent display of the fittings is desired, the cabinets should be simpler and more frankly mere housings. On the other hand, if the objective is a group of integrated lubrication units with a pleasing appearance, the fittings necessarily exposed in use should be built into, rather than on, the cabinets. Progress in this direction has been shown in modern gasoline metering pumps. —A. P. STEENSEN *The Foxboro Company*

Believes Urea Plastics Not Rated High Enough

To the Editor:

I have read with interest several PRODUCT ENGINEERING articles relating to plastics and would like to comment by saying that in some of the articles Urea plastics have not been given quite as good a rating as we believe they justify. In some instances, this is due to an attempt to coordinate data, neglecting certain perfunctory details, which creates an entirely different picture than that obtainable from all the facts.

As a point for discussion, we might take the so-called "Plastics Comparator" in the April number. In the table the "loss factor" for Ureas is listed in ninth place. We presume that the "loss factor" is the product of the power factor and the dielectric constant, neither value of which is indicated. Therefore, we must conclude that based on loss factor, Ureas are poor dielectrics for alternating currents. As a matter of fact, however, a mathematical rating for a plastic based on the product of the dielectric constant and the power factor is misleading. This is obvious to anyone acquainted with the behavior of alternating currents. Anyone reading the Comparator and not knowing the "missing data" would very well discard Ureas for dielectrics, yet as a matter of interest, Ureas have certain excellent electrical properties which are not even remotely indicated in the table.

It is my belief that during this period of plastics growth we cannot be too careful to give all the pertinent information so that engineers can more readily pick the proven plastic for a given application. Misuse of any plastic for a given job gives the whole industry a black eye, and somehow these black eyes last a long time.

"Plastics Comparator" is, no doubt, a fine addition to our present information on plastics, but like Dr. Kline's famous table on plastics, it should be used only for preliminary consideration as the authors indicate, the final considerations being worked out mutually by representative engineers of the companies involved. —M. H. BIGELOW *Toledo, Ohio*

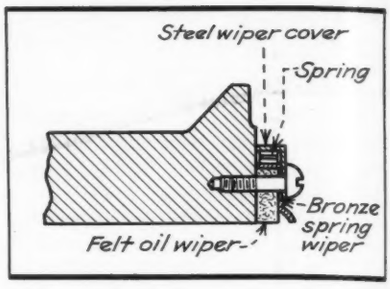
[*Editor's Note*—Referring to "Plastics Comparator," note that Urea plastics are rated No. 1 in dielectric strength.]

Scrapers and Wipers

To the Editor:

A noteworthy addition to the information on "Scrapers and Wipers" given in PRODUCT ENGINEERING for February, is this cross-section drawing. It shows the details of a spring tension scraper device with a felt wiper used for the wiping of bed ways on turret lathes made by the Gisholt Machine Company.

The spring wiper, made of bronze properly tempered to give it a spring effect while moving over the bed way,



has a tendency to scrape without scratching so as to remove all harsh particles such as grindings and shavings. The felt wiper mops up or absorbs the water or coolant.

—J. S. TAME *Chicago, Ill.*

Arc Welding Handbook

To the Editor:

I have just noticed on Page 287 of the June issue of "Product Engineering" wherein you erroneously state that the price of our "Procedure Handbook of Arc Welding Design and Practice" is $5.00.

Please accept our thanks for the compliment implied, but the price is $1.50, postage prepaid in the United States, $2.00 elsewhere. —A. F. DAVIS *Lincoln Electric Company*

Can You Work This One?

H. E. SMITH

Solution to June problem—

The Bookworm

Herman, the bookworm, ate his way through from page 1, Vol. 1 to the last page of Vol. 12 of a 12-volume set of law books. The volumes were arranged in numerical order, reading from left to right. In appeasing his appetite, Herman chewed a neat tunnel clear through the middle ten volumes, but because of the arrangement of the books, only had to eat through the first cover of Vol. 1 and the last cover of Vol. 12. Therefore, each volume being 2¾ in. thick with ⅛-in. covers, Herman's law course consumed exactly 27¾ in.

This month's problem—

Wine Dilution

A man named Julius was storing in his cellar a 10-gal. jar filled with a mixture of 60 per cent wine and 40 per cent water. One day his wife accidentally pushed the jar under a faucet which dripped into the wine at the rate of one pint per day in slugs of 0.001 gal. Forty days later, Julius discovered that his wine had been overflowing, and when he determined the cause, he was quite upset, not so much about the loss of a little wine, but rather about the dilution of his mixture. What percentage of the remaining solution was wine?

News and Summaries

High Surface Temperature Given as Cause Of Early Failure in Smooth Bearings

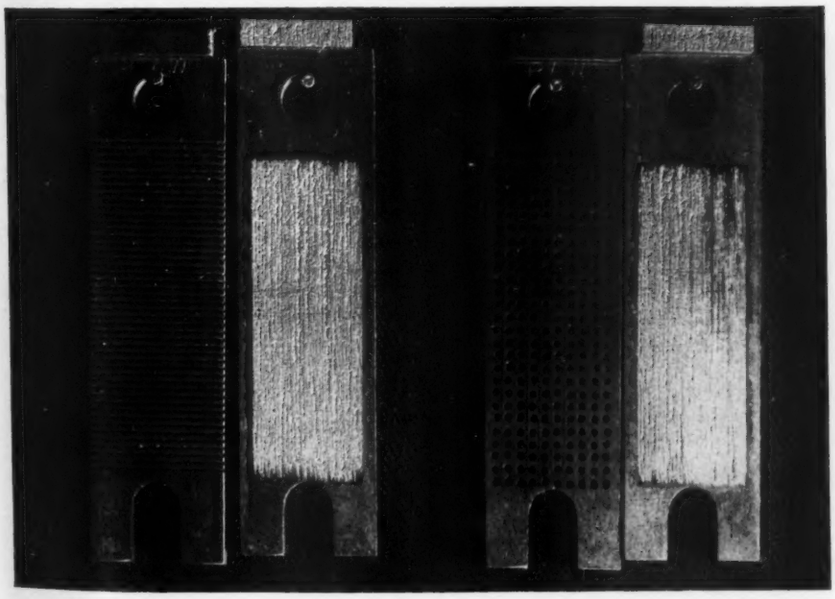
Experiments made under conditions of boundary lubrication indicate that interrupted surfaces create less surface heat, wear longer

HIGH SURFACE TEMPERATURE is the cause of bearing surface failure, according to Macy O. Teetor, research director of Perfect Circle Company, in a paper "Load Carrying Phenomena of Bearing Surfaces" presented before the Society of Automotive Engineers during their Summer Meeting. Mr. Teetor's paper, reporting results of experiments made on bearing surfaces with little or no lubrication, brought out two interesting facts: that the smoother the bearing surface the less the load bearing capacity, and that the load carrying capacity in lb. per sq.in. decreases as the contacting area increases.

In experiments conducted on sliding surfaces, using thermocouples located within a few thousandths of an inch from the surface, it has been determined that local surface temperature was often surprisingly high and could exceed 1,800 Deg. F., even though the mass of the metal was quite cool. Bearing surfaces undergo a change in finish and sometimes in structure as the surface temperature increases. If the areas in contact reach the melting point of the materials, the bearing fails, and scuffs, scores, cold welds, or chips.

The smoother the surfaces the easier it is to separate them with an oil film but maximum load carrying capacity is not reached until after lubrication has started to break down. After lubrication breaks down there are larger areas of contact if the surfaces are smooth than if the surfaces are rough. Since the areas of contact are the spots where surface temperature is generated, a smooth surface will generate more heat. Heat dissipation into the body of the bearing material remains constant for a given material, but there is more heat to be dissipated from the smoother surfaces. As a result, the temperature of a smooth surface can more quickly reach the melting point of the materials. It is true that a rougher surface has smaller points upon which to carry the load. But being farther apart, surrounded by cooler areas and possibly by some oil into which the heat can readily flow, the points of contact will carry more load before actually reaching the melting point of the materials. The scratches and grooves prevent the transfer of heat from one surface point to another.

An interesting example of this is given in the picture of two sets of specimens comparing plain ground surfaces with surfaces broken up into small bearing areas. In one set one bearing surface was interrupted with transverse grooves and in the other set small holes were drilled through one sample. The plain surfaces scuffed very badly in both instances but the interrupted surfaces were hardly scratched when subjected to the same conditions of wear.



These bearing samples, ground to same finish, were subjected to equal wear tests. Note failure of plain surfaces; interrupted surfaces remain unscratched

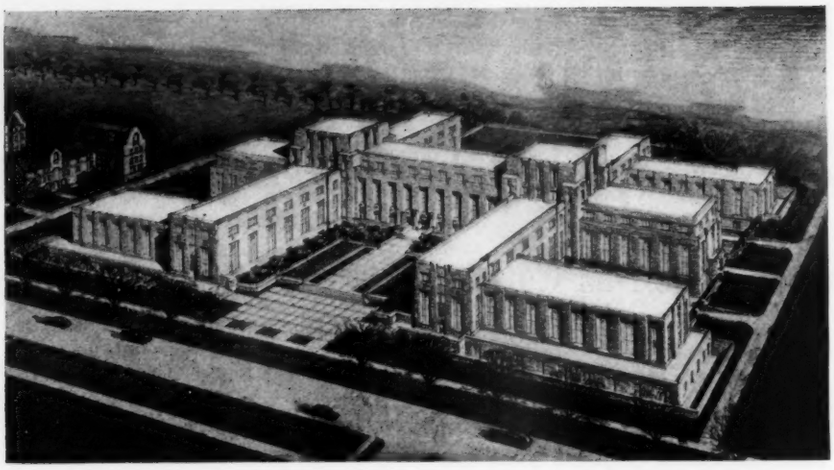
Grooved Piston Rings

From this research it would appear that an interrupted or cavitated bearing surface is more desirable than a continuous surface in some applications. Grooves in piston rings contribute to excessive oil consumption and a similar surface on a pressure lubricated bearing makes the maintenance of oil pressure difficult. These difficulties created by open grooves can be solved by filling them with a suitable material. Tests made on piston rings determined that deep grooves in the surfaces of the rings, when filled with black magnetic iron oxide greatly increased the life of the rings.

Northwestern Builds New Technological Institute

BEGINNING CONSTRUCTION of their new $5,000,000 Technological Institute building, Northwestern University is taking a forward step in the cooperative plan of engineering education. The Technological Institute is a new division of the University in which students spend alternate periods of the year attending classes and working in cooperating industries to obtain practical experience.

The new building, made possible last year by a gift of $6,735,000 from the Walter P. Murphy Foundation, will contain 450,000 sq. ft. of floor space



Northwestern's Technological Institute building, now under construction

and will provide laboratories, classrooms and offices for the chemistry and physics departments of the University and for the engineering divisions of the Technological Institute. Equipment will be valued at $1,350,000, including special laboratory machinery with a value of $500,000.

Under the cooperative plan of education, which has been used successfully for thirty-five years by many schools of engineering, students enroll in the Technological Institute on five-year courses in civil, mechanical, electrical or chemical engineering. During his freshman year the student spends the first three consecutive three-month quarters at the Institute and uses the fourth quarter as a summer vacation. At the beginning of the second year, he enters upon the program of alternation between classroom and industrial work and continues it until the completion of his fifth year. The student thus becomes familiar with practical techniques, trade terminology and human relationships, which are best learned by actual plant experience.

The cooperating employer may watch the progress of the student, and if the student shows promise, may give him special training.

Enrollment of students in the Technological Institute was begun in the fall of 1939 with the admission of a selected class of 100 students. The total enrollment of the Institute will be limited to 800 students.

Standards Bureau Tests Surface Treatments

HOT-DIP PHOSPHATE TREATMENT for both plain and galvanized surfaces showed outstanding merit in improving the protecting value of paint, reports the Bureau of Standards. Results of accelerated laboratory corrosion tests, including accelerated weathering, salt spray, and condensation corrosion tests, are described in Building Materials and Structures Report BMS44, which has just been released. Comparison of results is limited to the tests themselves, and conclusions are drawn on the basis of factors affected by conditions peculiar to the individual test.

Particularly effective protection was obtained when hot-dip phosphate treatments were used in combination with a primer of the inhibitive type. A phosphate cold wash for galvanized steel and two phosphate-chromate cold wash treatments for plain steel also appeared to improve paint protection. This report is the first of a series.

Nickel-Copper Steels Have High Durability

RESULTS OF CORROSION TESTS on low alloy sheet steels containing nickel and copper show that the beneficial effects of nickel upon the weathering resistance of steel increase with increasing nickel content, and are enhanced by the addition of optimum amounts of copper.

Transparent car, a Pontiac "repeat" for the 1940 World's Fairs, has crystal-clear Plexiglas body, complete except for the insulating material, to give an "X-ray" demonstration of uni-steel construction. Sheets for the larger panels were made from small sheets by softening fitted edges in liquid plexiglass and clamping together—a process which left a barely discernible seam in the finished job.

Hand scraping the surfaces of the molded Plexiglas parts removed slight imperfections resulting from heat treating and shaping processes. Special dies, accurately made from wood, steel and plaster, were necessary to draw and form the 5/32-in. sheets used for the fenders and the 1/8-in. sheets for the hood and body panels. Surfaces were highly polished after scraping which made the plastic translucent.

Results of a series of six tests, which have extended over a period of fifteen years in rural, urban, industrial and marine atmospheres, were reported by N. B. Pilling and Dr. W. A. Wesley, Director and Assistant Director of the Bayonne, N. J. Research Laboratory of the International Nickel Co., Inc., in their paper on "Atmospheric Durability of Steel Containing Nickel and Copper," at the Corrosion Session of the American Society of Testing Materials.

The superiority of nickel-copper steel is particularly pronounced in a marine atmosphere, tests here showing the nickel-copper steel containing more than 2 per cent alloy outlasted copper steel from 200 to 300 per cent at the end of six years' weathering. Results of tests on open hearth steels used in the droppers and bottoms of 50-ton railroad coal cars showed a two-to-one superiority for nickel-copper steels over unalloyed and copper steels after six years of service. The effects of manganese, silicon and carbon contents do not appear to be important, but the presence of a moderate amount of phosphorous seems to be beneficial in nickel-copper steels.

Do You Know That—

TORQUE WRENCHES, for drawing up a bolt to proper tension, are being recognized as a necessity to sound construction and assembly—so much so that one manufacturer has recently announced a complete new line of the wrenches. (16)

NICKEL-ALUMINUM and chrome-aluminum bonded sheets now available combine the beauty and durability of nickel and chromium with strength, and lightness of aluminum. (17)

Case Histories in Patent Law

H. A. TOULMIN, JR.

(EDITOR'S NOTE: *We wish to emphasize that in consenting to furnish this column wherein general explanations of the law in specific patent cases are set forth, Col. H. A. Toulmin, Jr., wants it clearly understood "that each actual case should be submitted to your own patent attorney who is the only one familiar enough to advise you accurately." The purpose of these explanations is to give a better general understanding of questions of patent law*).

No. 17

QUESTION: Who is presumed to be the first inventor when two persons make the same invention?

ANSWER: When two inventors have filed applications in the Patent Office for the same subject matter, the Patent Office determines this conflict of application by declaring an interference in order to determine who is the actual first inventor. This is a contest, like a lawsuit, held in the Patent Office and decided by the Patent Office officials. Testimony is taken by the respective parties after pleadings have been filed setting forth the dates that they claim. These statements of their dates are filed under seal and are retained under seal during certain preliminary stages of the interference. During this sealing period either party may make a motion to dissolve the interference on the ground that the other party does not have the right to make the claims that are in issue in the controversy. This is one of several different grounds upon which motion to bring about the dissolution of the interference can be made.

When the time for making these motions has expired, and all motions filed during the time allowed are disposed of, then the preliminary statements giving the dates of the respective parties are opened up.

A Patent Office interference is one of the most complicated legal procedures known in the United States. It is based upon a vast host of very technical rules. Merely being the first to conceive the idea, or even to disclose it and show it in drawings, is not enough to insure that you will be declared the first inventor. In addition to this, you must be diligent at the time and shortly before your opponent comes into the field with his invention. One of the important factors is to determine who was the first to reduce to practice, i.e., who was the first to actually make and successfully test the apparatus. Of course, the filing of the application in itself is regarded as a constructive reduction to practice, but often the actual reduction to practice takes place many months before the filing of the application.

The first to file an application is the senior party and is presumed to be the inventor. He has, according to statistics, about three chances out of four to win the interference. It is incumbent upon the second to file, who is the junior party, to carry the burden of proof to prove that he is the actual inventor. This is due to the fact that he was not as diligent as the first applicant to file his application and must overcome his delay by proving that he was, in fact, the first inventor.

The parties take testimony, the first party to file being the last to take the testimony. The witnesses appear before a Notary Public and are examined and cross-examined by the respective counsel. This testimony is then filed in the Patent Office, briefs are prepared and the lawyers appear before a board of three Examiners in interferences, who determine the question of who is the first inventor.

If the inventor who loses is dissatisfied with the decision of the Patent Office, his appeal lies to the United States Court of Customs and Patent Appeals. In case the losing party is an applicant, he can, if he desires, file a complaint in the United States District Court in the District where the prevailing party resides. The losing party may proceed in either of these ways, but not both ways.

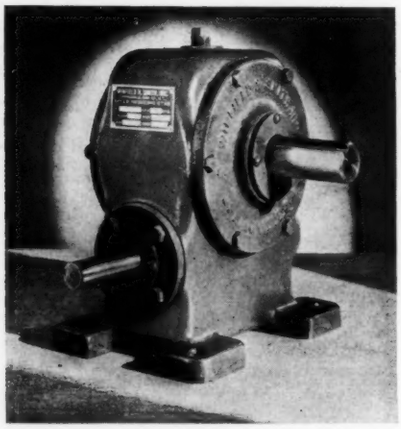
A very important new rule has been put into force by a new law just passed by Congress that a request for an interference based upon taking a claim from an issued patent will not be considered unless that request is made within one year from the date of the issuance of the patent. This necessitates a very careful study of all the patents issued to competitors as they are published in the Official Gazettes, so that they can be compared with any pending applications and a prompt request be made to put the pending applications and the issued patents in interference. In the event that such interference is declared, no motion can be made on the ground that the interfering claims lack patentability because the Patent Office has already decided that issue by issuing such claims in an issued patent. This rule, of course, does not apply when only pending applications are placed in interference with one another.

This determination of whether or not there is interference is a matter very largely of law and should not be attempted by an engineering department. Simply ordering copies of patents from the Gazette and trying to determine whether there is any interference is a hard and often inaccurate method.

New Materials and Parts

Worm Gear Speed Reducer

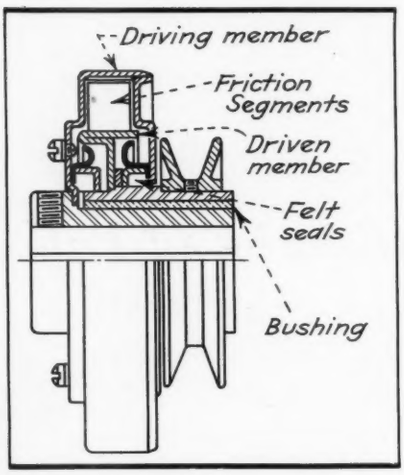
Full anti-friction bearing equipped worm gear speed reducer, known as No. 4½B, has the high speed shaft supported in radial-thrust ball bearings, and the slow speed shaft supported in Timken bearings. The worm, integral with the shaft, is hardened and ground. The gear is of high-grade alloy bronze. Oil seals of the built-in type are on both



worm and gear shafts. Available in ratings of ¼ to 2 hp., with torque capacities from 567 in. lb. at 60–1 ratio to 1,095 in. lb. in ratios as low as 6-1. Winfield H. Smith, Inc., Springville, Erie Co., N. Y.

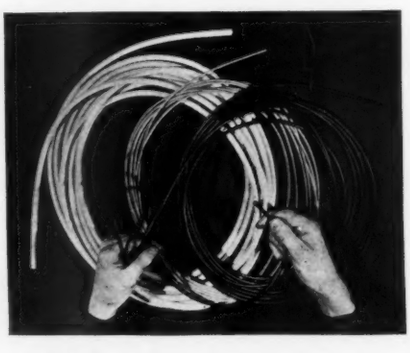
Mercury Clutch

Utilizing mercury to displace friction segments by centrifugal force, this clutch permits a driving motor to gain speed before assuming load. Only four principal parts comprise the clutch: the driving member or housing, the driven member or inner drum, the clutch segments and the mercury. In operation, mercury displaces the clutch segments inward, where they engage the drum at the proper time and speed, a positive drive being effected when the speed of the housing and driven drum are synchronized. It is possible to predetermine the time and speed of engagement. Overloads and other shocks are not transmitted through the clutch to the prime mover, the capacity of the clutch limiting the torque transmitted. At present, 4- and 4½-in. diameter sizes are standard, transmitting loads up to 5 hp. Other sizes available on specification. Mercury Clutch Corp., 637 W. 3rd St., Massillon, Ohio.



Extruded Tubing

Showing great improvement over varnished tubular cotton braids under many conditions, a new development in



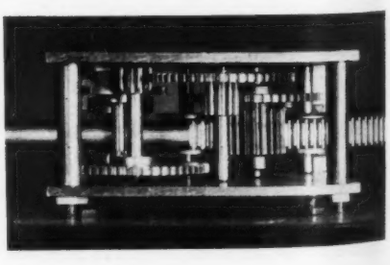
plastic materials is an extruded tubing manufactured in continuous length. This tubing has outstanding mechanical strength, greater flexibility, improved tear and abrasion resistance, greater solvent resistance, increased heat resistance, and is more fireproof than any former similar type of material. It is not affected at soldering temperatures, and does not lose its form up to 300 deg. F. The new product is produced in five standard colors from size No. 20 to ⅝ in., but can be manufactured in different sizes and wall thicknesses as specified. It is known as Irv-o-lite Type XTE-30. Irvington Varnish & Insulator Co., 24 Argyle Terrace, Irvington, N. J.

Lubricating Coating

Surfaces not readily capable of lubrication by ordinary means can now be pre-lubricated by a new stable and highly adherent lubricating coating. The coating is applied in liquid form, either by dipping, brushing or spraying, and hardened on exposure to light, providing a relatively high resistance to abrasion and excellent lubrication and corrosion prevention characteristics. Basic element providing lubrication is colloidal graphite while the presence of small amounts of hardenable organic colloids and a hardening agent, in a water suspension, render the composition photo-hardening in character. The coatings can be applied at normal temperatures or to surfaces heated up to 100 deg. C. to promote rapid drying. Lubricating characteristics are not affected by operation of the surfaces at elevated temperatures. A similar process can be used to prepare non-conducting materials for electroplating. Acheson Colloids Corp., Port Huron, Mich.

Gear and Escapement Mechanism

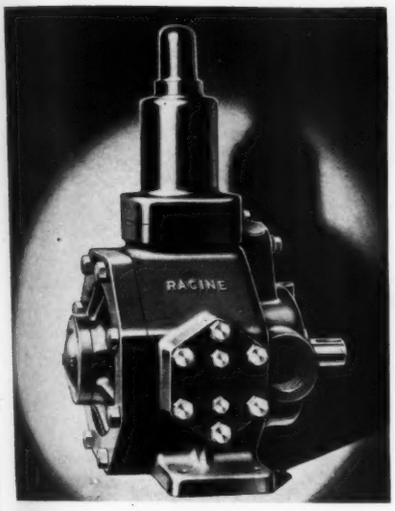
Consisting of a train of heavy gears, pinions and a gear rack, this mechanism may be adapted for mechanical tripping or electric control operation in fixed or adjustable intervals and single or repeat operating cycles. When operated by weight or spring, the rack drives the gear train through a ratchet-held loose pinion which, on reverse motion, is released to permit the rack to be



manually or electrically returned to its starting position. Constructed of heavy brass and steel with gears and pinions cut from solid stock. A variety of timing ranges from a few sec. up to approximately 3 min. is possible, depending upon the gearing, length of rack and operating weight utilized. Walser Automatic Timer Co., 420 Lexington Ave., New York, N. Y.

Variable Volume Hydraulic Pump

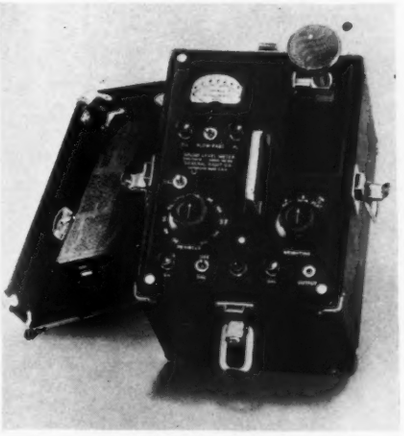
Variable volume hydraulic pump, rated at 1,000 lb. per sq. in. continuous pressure, contains many new features. The shaft is of a larger diameter, with wide margin of safety against deflection



under maximum load or shock. Needle bearings are wider and of larger diameter. Oil seals of mechanical self-compensating type, prevent leakage at the shaft end and seal against atmospheric pressure only. Vanes and rotors are heat-treated, hardened and ground. Pressure chamber ring is double heat-treated, hardened and ground, imparting a smooth, harmonic action to the vanes and preventing gouging and wear. In addition to the variable volume constant pressure fature, which is obtained by a single type of hydraulic governor, the pumps are also furnished with manual handwheel for positive control of volume. Racine Tool & Machine Co., Racine, Wis.

Sound-Level Meter

The new Type 759-B Sound-Level meter meets the standard specifications for sound-level meters as adopted by the American Standards Association and various engineering societies. Features of the new instrument are accuracy, rugged construction, convenience in operation, and portability. A two-speed indicating meter with selector switch is provided. In the "fast" position of the



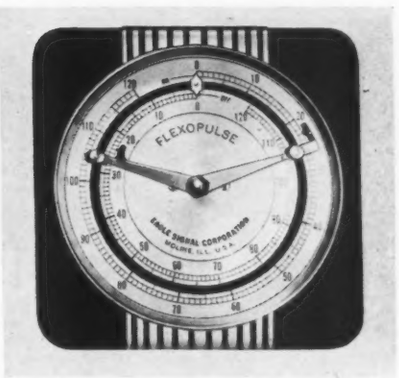
switch, the meter speed conforms to ASA specifications. In the "slow" position, the meter is heavily damped and can be used for measuring the average value of rapidly fluctuating sounds. New types of vacuum tubes and batteries give reliable operation and long life. General Radio Co., 30 State St., Cambridge, Mass.

Capacitor Motors

Permanent split capacitor motors have an aluminum case, and can be ventilated or partially or totally inclosed. The motor shaft carries a large cooling fan. Windings are for capacitor start and run operation. The motor has no starting switch and operates at exceptionally high efficiency for small hp. The motors can be wound to run at approximately 1,100, 1,650 or 3,300 r.p.m. and for single phase a.c. of 25, 50 or 60 cycles. They are built for flange mounting, horizontal or vertical, with shaft extension up or down. Vertical motors have porous bearings and horizontal motors have bronze bearings with wool wick oil reservoirs. The capacitor can be mounted on the motor as shown or at any nearby location. Ohio Electric Mfg. Co., 5911 Maurice Ave., Cleveland, Ohio.

Repeating Cycle Timer

An extreme range of contact in a continuously repeating series of operations is provided by the new "Flexopulse" repeating cycle timer which utilizes reversing action without reversal of motor. One of the features of the timer's design is that cycle and percentage of



contact closure time may be adjusted without changing gears or adjusting cams. Three distinct models providing ranges of 2 to 120 sec., 20 sec. to 20 min., and 2 to 120 min. are available. All models have 5¾-in. diameter clock face dials with time adjustment arms for cycle regulation. Eagle Signal Corp., Moline, Ill.

Vibration Isolator

Designed to economically control machine vibration and reduce noise. Device known as controlled spring isolator was developed for use on bases of equipment where vibration and excessive motion create noise and tend to wear out machine parts. Working

parts of the unit consist of a coil spring and a rubber load pad, which support equipment. An adjustable rubber snubber inside the base controls excessive motion. Isolator is built to take care of horizontal and torsional as well as vertical vibration. Johns Manville, New York City.

Braided Packing

Braided packing, known as Lattice-Braid packing, has a distinctly new braided construction, giving longer service than ordinary square or round braided packings. Controlled porosity of the packing obtained with lattice-braid construction, imparts to the material a semi-automatic action brought about by a combination of a mechanical

pressure which the gland brings to bear upon the packing, and the fluid pressure which is being confined by the packing. The structure of the packing, regardless of the lubrication treatment, is capable of absorbing high pressure without breaking down the packing, and without setting up excessive interfacial pressure, or friction, between the packing and at the rod or shaft. Lattice-Braid packing, no matter how badly worn, will not disintegrate into a series of loose strands or separate parts. Flexibility is improved. Garlock Packing Co., Palmyra, N. Y.

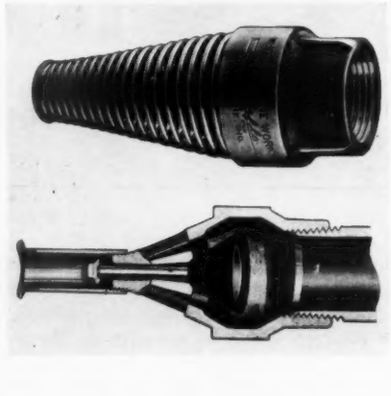
Coolant Pumps

Especially designed for machines requiring only a moderate volume of coolant, a new line of smaller coolant pumps are made in various types and capacities. Essential features are: a built-in motor, rugged vertical shaft

suspended on precision ball bearings, double suction intake which provides a balanced impeller, and special constructional details which permit simple and easy installation on both old and new machine tools. They have no packing nuts, foot or relief valves and require no priming. Their patented double intake and balanced thrust impeller is built without metal to metal contact. Known as the "Gusher" model P-3, the pump can be throttled down to trickle. Four standard types of mountings are available. The Ruthman Machinery Co., Cincinnati, Ohio.

Foot Valve

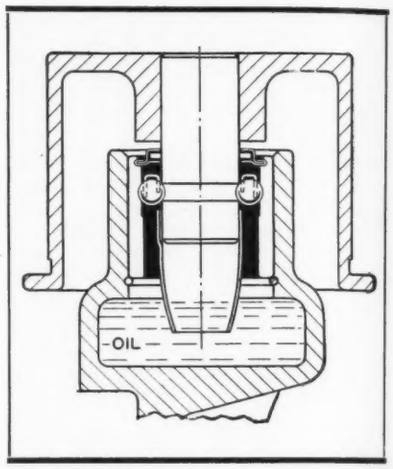
Unique valve design, with an all-rubber and collapsible conical poppet, is designed to eliminate leakage and reduce "lift" created by the foot valve to almost nothing. "Strateflo" foot valves



have a one piece cast brass body, and a helical wound brass spring wire strainer, self-cleaning and indestructible. There are no springs, practically no flow restriction, and no loss of head. Tests have shown that the poppet will hold tight because of the flexible action of the soft rubber lip of the poppet, even when held from the seat by grit, or when the seat is distorted in shape. White Machine Works, Fort Wayne, Ind.

Pulley Bearing

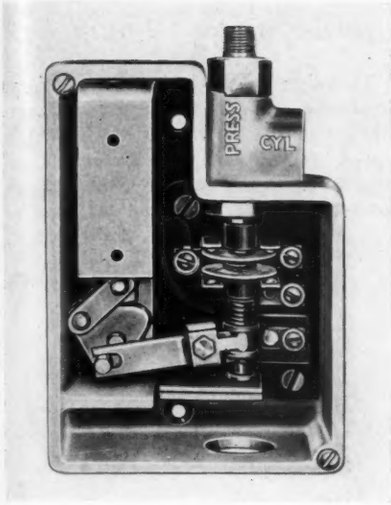
Vertical tension pulley bearing for textile machinery, identified as No. TP-13-500, is unique in design in a number of respects. The bearing not only provides a vertical stub shaft on which the



pulley is mounted, but it contains its own oil circulating system for speeds of 3,500 to 15,000 r.p.m. By this system, oil is drawn from a reservoir below the bearing and is passed in a fine spray or mist directly to the balls and races. Since the bearing is of the self-sealed type with all-metal seals, the oiling system is completely inclosed and oil need be added only at yearly intervals. The bearing requires no locknuts, screws or other parts, and it may be removed instantly without tools for reoiling. New Departure, Div. General Motors Corp., Bristol, Conn.

Solenoid Valve

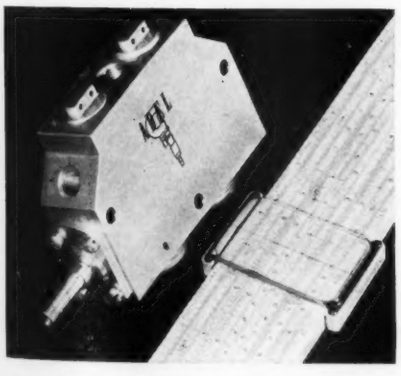
This new valve, for air at pressures up to 75 lb. per sq. in., is designed for pilot control of single acting, gravity or spring return, cylinders or diaphragms. Valves are tight seating, and are completely free from a.c. hum. The valve requires no continuous operating current, being mechanically held in either position after momentary energization



of the solenoid. A cast aluminum box, with sheet metal nameplate cover, includes the valve body as an integral part and forms a casing for the single coil operating movement, control contacts and terminals. Each seat and disk with its spring is contained in a brass housing. The seat, which has a $\frac{5}{32}$-in. diameter port, is integral with the housing; the disk is of oil-proof composition. Delicate control contacts can be used with this valve, since the control station makes but never breaks the operating current, the breaking operation being performed by contacts mounted with and operated by the solenoid. Automatic Switch Co., 41 E. 11th St., New York. N. Y.

Hydraulic Selector Valve

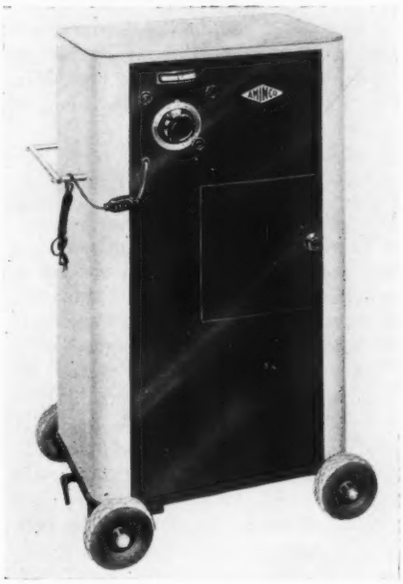
New line of four-way hydraulic selector valve is designed to obtain the ultimate in simplicity, while at the same time effecting very substantial space and weight saving. The smaller of the new



Adel valves measures only 3 x 2½ x 1 in. and weighs but slightly over 12 oz. Operating handle loads as low as 15 in. lb. are obtained while operating under 1,000 lb. per sq. in., which means that valves may be actuated with an applied force of less than 4 lb. on a 4 in. handle. Models are available for capacities in excess of 15 gal. per min. and fitted for either straight or pipe threads. Adel Precision Products Corp., Burbank, Calif.

Area Determinator

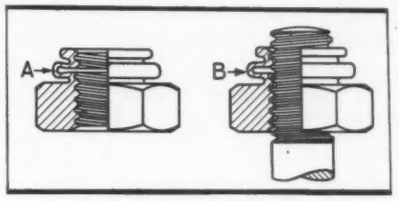
An instrument for the rapid measurement of the area of any flat object of any shape, color or texture that will fit into a circle 9.93 in. in diameter, eliminates tedious, time-consuming and less accurate planimeter measurements. It is



accurate within 3 per cent of the true area. Reproducibility, within 0.2 per cent. This accuracy is not affected by the experience of the operator or the nature of the object's outline. Measured area is read directly from a dial. The instrument operates directly from house current supply. Housing is mounted on four wheels having pneumatic tires. Complete details are given in bulletin PE-2081. American Instrument Co., Silver Spring, Md.

Self-Locking Nut

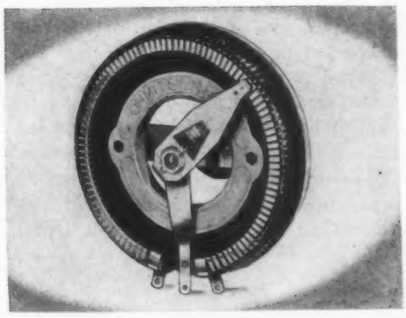
The Boots self-locking nut is an effective one-piece, all metal nut designed to withstand the most severe vibration. It is essentially two nuts in one, with the top section displaced in a downward direction so that its upper threads are out of lead with respect to the load-carrying threads of the lower section. The two sections are connected by a spring member which is an integral part of the nut. Upon insertion of a bolt, the spring member allows the top section of a nut to be extended to permit it to engage properly with the threads



of the bolt. A force is thus established which firmly grips the nut without damage to the threads of the screw or bolt and accommodates all thread variations. Available in sizes from No. 8 to ¾ in. inclusive, in a variety of metals. Scovill Mfg. Co., Waterbury, Conn.

750 Watt Rheostat

This new unit, filling in between the 500 and 1,000 watt rheostats, is similar to all other Ohmite rheostats. Resistance wire is accurately wound on a solid porcelain core, and perfectly insulated by Ohmite vitreous enamel which separates the individual turns of wire and binds the entire assembly rigidly to the core. There is nothing to smoke, char, shrink or shift. The rheo-



stat dissipates heat rapidly and is mechanically strong. Shaft and mounting are insulated from all parts which are electrically "live". Large copper graphite contacts are used to combine long life and negligible contact resistance. Model "T" is 10 in. in diameter, with ⅜ in. shaft. Ohmite Mfg. Co., 4835 Flournoy St., Chicago, Ill.

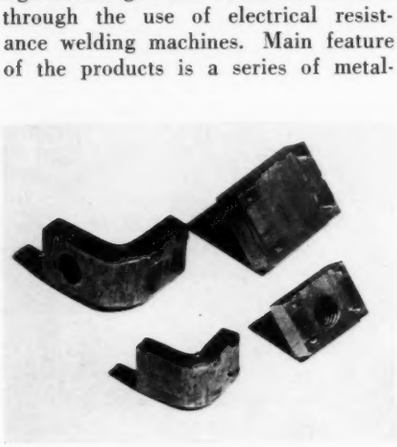
Infra-Red Baking Enamel

New enamels, especially designed to work at high speed baking schedules in infra-red lamp ovens, allow the finisher to take full advantage of the more rapid baking and very short warming-up peri-

ods afforded by infra-red ovens. With infra-red heat, the enamels will bake to a very hard durable surface in 15 to 20 min. and can be handled for assembly half an hour later with little danger of marring. Raydur enamels are available with high gloss, semi-gloss and wrinkle finishes. Furnished in black, white and most colors. Maas & Waldstein Co., 438 Riverside Ave., Newark, N. J.

Welding Nuts

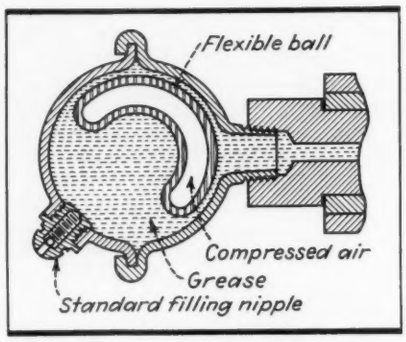
Nut products, consisting of rectangular welding nuts, rectangular welding bosses and welding brackets give the design advantages and economies available through the use of electrical resistance welding machines. Main feature of the products is a series of metal-



lic projections on the side of the nut or bracket to be welded. The welding brackets, bosses or nuts should be made of the same material as the parts to which they are welded. Available for production in many sizes, and can be furnished with holes drilled, reamed or tapped to a number of sizes. Ohio Nut & Bolt Co., 600 Front St., Berea, Ohio.

Pressure Lubricator

Utilizing compressed air, this lubricator consists of a steel shell designed to withstand high pressures, inside of which is a hollow flexible neoprene ball. The shell is equipped with a standard grease fitting and a pipe-threaded outlet that screws into the standard lubrication passage. When grease is forced into the lubricator by a pressure gun attached to the grease fitting, it collapses the neoprene ball against the pressure of the air inside of it, thus compressing the air and storing up energy. After the lubricator has been filled under high pressure, the grease flows through the bearing rapidly with a flushing action until the pressure within the lubricator drops to where it balances with the resistance



of the bearing to passage of lubricant. When this static condition has been reached, further lubricant is forced to the bearing only when the bearing is in motion. It can be used to replace grease fittings or oil cups of various types on machinery. Simplex Mfg. Co., 1504 Broadway, Detroit, Mich.

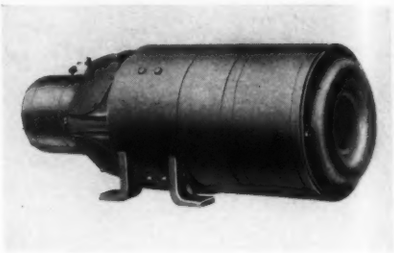
Drafting Table

Hamilton Streameline table has a base made of tubular steel, welded to insure rigidity and finished in satin chrome. The drawing surfaces are made of selected California sugar pine, claimed to be the finest material for drawing boards known. Steel bracing is finished in black wrinkle finish. A wide foot rest runs the entire width of the table. Legs of the table are equipped with hard rubber shoes to prevent damage to floors. Drawing

board can be instantly set at any angle from horizontal to full vertical. A positive release mechanism at the left hand side of the board locks the board at any angle. Height of the board is adjustable from 33½ in. to 42 in. This adjustment is controlled by four hand wheels, one in each of the tubular steel legs. Where frequent height changes are necessary, an auxiliary gear-raising device operated by a crank is available. Hamilton Mfg. Co., Two Rivers, Wis.

Speed-Variator Equipment

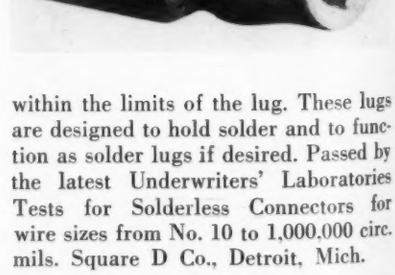
Complete speed-variator equipment operating from an a.c. source of supply provides wide ranges of adjustable speed by means of the well-known generator-voltage-control scheme. Each equipment consists of an adjustable-



speed d.c. motor, and an adjustable voltage motor-generator set with control shown in the illustration, and a separately mounted generator-field rheostat. Standard speed ranges are available up to 16:1 ratio. The adjustable-speed motor can be mounted directly on the driven machine, with speed-changing control mounted nearby. Speed control is obtained in small increments over wide ranges. Units are designed to operate from 3-phase, 60-cycle, 220-, 440- and 550-volt a.c. power. General Electric Co., Schenectady, N. Y.

Solder-Solderless Connectors

New connector may be used either as a solderless connector or as a solder lug. Each connector covers a wide range of wire sizes which may be required for the device with which it is used, and has only two parts—a cast lug and a special set screw. The inside of the lug is shaped to obtain maximum holding power and all the wire sizes



within the limits of the lug. These lugs are designed to hold solder and to function as solder lugs if desired. Passed by the latest Underwriters' Laboratories Tests for Solderless Connectors for wire sizes from No. 10 to 1,000,000 circ. mils. Square D Co., Detroit, Mich.

Manufacturers' Publications

Materials

BRASS AND COPPER—Revere Copper & Brass, Inc., 230 Park Ave., New York, N. Y. Weights and data book, 172 pages, 8½x11 in. Contains practical and complete recalculated tables of weights and data on copper, brass, and bronze products.

LAMINATED PLASTICS—The Formica Insulation Co., Cincinnati, Ohio. Formica Data Book, 28 pages, 8½ x 11 in. Tells the how, where and why of uses for Formica, a laminated plastic product applied as insulation in electrical devices, as mechanical parts and for chemically resistant parts. Tables of properties are included.

MECHANICAL RUBBER—B. F. Goodrich Co., Akron, Ohio. Bulletin 40-8581-GM, 24 pages, 8½x11 in. This condensed catalog gives engineering data and is a guide to the selection of various mechanical rubber products. Rubber belts, conveyor belting, hose and hose fittings are all included.

NICKEL ALLOYS — The International Nickel Co., 67 Wall St., New York City. 16-page pocket size edition, "Seven Minutes with Metals", includes material on nickel, monel, inconel and associated alloys in both mill and clad forms. 3 pages devoted to detailed tables on mechanical, chemical and physical characteristics.

STAINLESS STEEL—Republic Steel Corp., Republic Bldg., Cleveland, Ohio. Four booklets: Form ADV 361, 28 pages, 8½x11 in.; Form ADV 362, 24 pages, 8½x11 in.; ADV 363, 24 pages, 8½x11 in.; and Form ADV 364, 16 pages, 8½x11 in. List properties, give fabrication details, and show application of Enduro stainless steel.

STEEL—Joseph T. Ryerson & Son, Inc., 16th and Rockwell Sts., Chicago, Ill. Catalog 1940, 256 pages, 4¾x8½ in. Gives dimensional data, weights and prices of all types of structural, sheets, tubes, bolts, etc. Indexed for convenience.

Mechanical Parts

BEARINGS—Ahlberg Bearing Co., 3062 W. 47th St., Chicago, Ill. Catalog 440, 96 pages, 8½x11. Contains dimensional data on all types of ball bearings, tapered roller bearings, straight roller bearings, thrust bearings, and ball bearing pillow blocks.

ELASTIC STOP NUT—Elastic Stop Nut Corporation, 2332 Vauxhaul Road, Union, N. J. Bulletin L40-10, 4 pages, 8½x11 in. Concise explanation of construction and self-locking action of elastic stop nut and a graphic listing of the advantages to be obtained through their use.

LIMITORQUE CONTROL — Philadelphia Gear Works, Philadelphia, Pa. Bulletin 1, 66 pages, 8½x11 in. Illustrates and gives full information on controls for operating valves from 3 in. to 96 in. in diameter.

LUBRICATOR AND FILTER—C. A. Norgren Co., Denver, Colo. Catalog 300, 20 pages, 8½x11 in. Describes Norgren automatic sight feed airline lubricator.

OILERS—Gits Brothers Mfg. Co., 1846-62 S. Kilbourn Ave., Chicago, Ill. Bulletin 10, eight pages, 8½x11 in. Sets forth features, with illustrations and prices, of the Gits sight gravity and wick feed oilers.

PACKING—Belmont Packing & Rubber Co., 3636 Sepviva St., Philadelphia, Pa. Every page of this catalog contains a complete visual and written record of the packing described, concisely detailed so as to instantly supply full information about any given packing.

ROTARY PUMPS—George D. Roper Corp., Rockford, Ill. Catalog 939, 124 pages, 8½x11 in. Sets forth features of the new Roper pump line, and contains a generous amount of engineering data helpful to beginner and experienced alike.

SPEED REDUCERS—D. O. James Mfg. Co., 1114 W. Monroe St., Chicago, Ill. Catalog 18, 40 pages, 8½x11 in. Contains many pages of selection tables, classified by service and character of load, facilitating choice of motorized worm gear reducer.

SPEED REDUCERS—Winfield H. Smith, Inc., Springville, Erie Co., N. Y. Catalog 140, 36 pages, 8½x11 in. Illustrates and gives specifications for complete line of speed reducers. An index is included to help in the selection of the proper unit.

VARIABLE SPEED TRANSMISSIONS—Lenney Machine & Mfg. Co., Warren, Ohio. Catalog, 12 pages, 8½x11 in. Sets forth salient features, with complete engineering information, of the new Lenney variable speed transmission.

VIBRATION CONTROL—The Felters Co., Inc., 210 South St., Boston, Mass. "Unisorb In the Industrial Plant", 24 pages, 6x9 in. Explains in detail the types of installations made with Unisorb felt classified by type of industry.

VIBRATION ISOLATORS—Korfund Co., Inc., Long Island City, N. Y. Bulletin BA-22, 4 pages, 8½x11 in. Describes installation without a concrete foundation of a 150-hp., 4-cylinder diesel generator, mounted on Korfund steel spring Vibro-Isolators and the new Korfund Vibro-Stabilizers.

Electrical Parts

CONNECTORS—Burndy Engineering Co. Inc., 459 E. 133rd St., New York, N. Y. "Electrical Connector Guide", 16 pages, 5x7 in. A handy method for making a survey of electrical connections. Includes a guide chart for the proper selection.

CONNECTORS—Sheldon Service Corp., Long Island City, N. Y. Bulletin, 6 pages, 8½x11 in. Illustrates and describes the Sheldon Splitbolt connectors which incorporate a new principle for permanently holding two wires together with a high gripping pressure.

HEATING UNITS—General Electric Co., Schenectady, N. Y. Three bulletins on electric resistance heating units: Bulletin GEA-1157C, 4 pages, 8x10½ in., strip heaters; Bulletin GEA-104B, 2 pages, 8x10½ in., cartridge-type heating unit: and Bulletin GEA-2618A, 4 pages, Fin Calrod heating units for forced convection air heating.

MOTORS—General Electric Co., Schenectady, N. Y. Bulletin GEA-3307, 4 pages, 8x10½ in. Self-starting, synchronous inductor motors for electrical instruments, small regulating devices, and applications where low speed torque is required.

RESISTORS—Sprague Products Co., North Adams, Mass. Catalog 12, 8 pages, 8½x11 in. Gives salient features of and engineering data for complete line of Sprague Kool-ohm Resistors.

Finishes

ELECTRODEPOSIT TESTING—E. I. du Pont de Nemours & Co., Wilmington, Del. Technical Service Bulletin describes the application of the "Hull and Strausser" test of electrodeposit thickness to zinc, cadmium, tin and copper.

FAST BAKE FINISH—Ault & Wiborg Corp., 75 Varick St., New York, N. Y. "The Facts on Polymerin", 32 pages, 4½x 6 in. This manual of information on speed finishing applications and methods, describes how Polymerin industrial finishes are being used in various industries.

Miscellaneous

BALANCING MACHINES—Gisholt Machine Co., Madison, Wis. 32-page 8½x11 in. booklet. Describing the Gisholt line of static and dynamic balancing machines for locating and measuring unbalance in rotating parts, including detailed explanation of the effects of unbalance in rotating parts with diagrams and descriptions of the underlying principles of the machine.

DRAFTING ANGLE—Edwin Z. Lesh, East Hartford, Conn. Leaflet describes the improved Lesh angle which can be adjusted to any required angle.

Books and Bulletins

Engineers and Engineering in the Renaissance

William Barclay Parsons—661 pages, 6⅞x10 in. 211 illustrations. Published by Williams and Wilkins Company, Mt. Royal and Guildford Aves., Baltimore, Md. Price $8.

The result of many years' patient research, this volume presents a history of engineering achievement remarkable for its completeness and authenticity. General Parsons, widely known engineer and scholar, spent much of his life collecting and sorting the material in this book, which was unfinished at the time of his death in 1932. However, nothing has been added or changed, and because of this, the book is published as a collection of papers rather than as a continuous narrative.

Engineers will be much interested in the curious mechanical contrivances illustrated and discussed in Part II of the book which covers the invention and application of machines. General Parsons devotes 75 pages to an interesting appraisal of the valuable engineering contributions of the great Florentine, Leonardo da Vinci. Many of his structural and military drawings are reproduced.

Plastics in Engineering

J. DELMONTE—*608 pages, indexed and illustrated. 6x9¼ in. Blue clothboard covers. Published by Penton Publishing Company, Cleveland, Ohio. Price $7.50.*

Mr. Delmonte, widely known in the plastics field, presents in this volume a comprehensive analysis of plastic materials for the designing engineer. Accordingly only a brief review of the history and chemistry of plastics is attempted, the main emphasis being placed on properties, molding and mold design, and on engineering applications of organic plastics.

The book discusses numerous applications of plastics to machine design problems, all data being tabulated and referenced for convenience. So that the designer may have a full understanding of potentialities and limitations of these materials, advantages and disadvantages of the various types are fully discussed in terms of definite engineering problems. In addition, a separate chapter is devoted to discussing limitations of the more common plastic materials, and the reasons for these service failures pointed out. Other chapters discuss hot and cold molding mold design, mold construction, and non-metallic bearings, gears and cams. Surface coatings, synthetic rubbers and rubber-like resins, test methods and data on comparative costs are also covered in separate chapters.

The Physical Examination of Metals

BRUCE CHALMERS—*Volume I, Optical Methods. 180 page, 5½ x 8½ in. Blue clothboard covers. Published by Longmans, Green & Co., New York. Price $5.*

The object of this book is to explain the physical theory and applications of optical methods of investigating properties of metals. These properties have been virtually unknown to metallurgists who have not had special training in physics. The author explains in simple language the latest applications of interferometers and polarized light to metallurgical work. Six chapters deal with geometric optics; wave optics—interference; wave optics—diffraction; polarized light and finally sources of light. Complete references are furnished throughout the text.

Machine Design Drawing Room Problems

C. D. ALBERT—*441 pages, 6x9 in. Blue clothboard covers. Third edition, revised. Published by John Wiley & Sons, Inc., New York City, $3.50.*

Complete comprehensive problems presented in the first half of this book offer material for a drawing room course in general machine design. Thirteen design problems are given in as many chapters arranged in accordance with their length and the time necessary for solution.

Value of this book lies in the last nine chapters which are a reference to sound information on engineering materials, allowable stresses, straight and helical spur gears, worm gearing, graphics, tolerances and allowances for metal fits, bearings, screw threads, screw fastenings and miscellaneous information in tabular form.

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Index to A.S.T.M. Standards

1940 Edition, 152 pages, 6x9 in. Published by American Society for Testing Materials, 260 S. Broad St., Philadelphia.

The Index is of service to anyone wishing to ascertain whether the Society has issued standard specifications, test methods, or definitions covering a particular engineering material or subject and it is of help in locating the standards in the volumes where they appear.

All items are listed in the Index under appropriate key-words according to the particular subjects they cover. As a convenience a list is given of the specifications and tests in numerical sequence of their serial designations.

Hydraulic and Pneumatic Leather Packing Design and Applications

Booklet, 50 pages, 8½x10¾ in. Published by Chicago Belting Company, Green and Washington Streets, Chicago, Ill.

Discusses the types, design and applications for leather packings with dimensional sketches showing various constructions of stuffing boxes; glands; piston, spindle and ram heads; methods of sealing piston rod and plate joints; heel corner radius and lip bevels; use of spacers and spring expanders; surface speeds at various pressures; temperature limits; choice of packing style; and packing specifications. One page is devoted to 18 "don'ts" for hydraulic and pneumatic packings.

Artificial Light and Its Application

296 pages, 8½x11 in. Spiral binding. Published by Westinghouse Lamp Div., Westinghouse Electric & Mfg. Co., 150 Broadway, New York, N. Y. Price $1.25.

Covering every phase of the lighting field, this up-to-date source book is presented in terms interesting alike to lighting engineers, students and laymen. The book can be used by engineers as a handy reference manual for all types of lighting problems. Over 400 photographs, sketches, line drawings, pictorial tables and graphs are used to illustrate recent developments in fluorescent, electrical discharge and incandescent lamps.

Beginning with chapters covering the history and general considerations of light, the book describes in a clear and comprehensive way the methods for lighting all types of buildings and work-areas, and includes such subjects as floodlighting, sports lighting, electrical advertising, germicidal radiation, and photographic lamps. Each chapter gives a complete discussion of its subjects, and can be purchased individually at 7 cents each.

BRASS BUSHING STANDARDS

A. C. RASMUSSEN
Chief Engineer, Insley Manufacturing Company

THIS TABLE gives dimensions and tolerance limits for brass bushings, both before and after burnishing, and for the ground and hardened shaft and the housing bore. It can be used for all bushing details except where in-between sizes are absolutely necessary, in which case tolerances for the next larger standard bushing should be used. If cold-rolled shafting is used, since these shafts are generally rolled a few thousandths of an inch over their nominal size, the amount of oversize should be added to the diameter of the burnished hole to obtain the proper clearance.

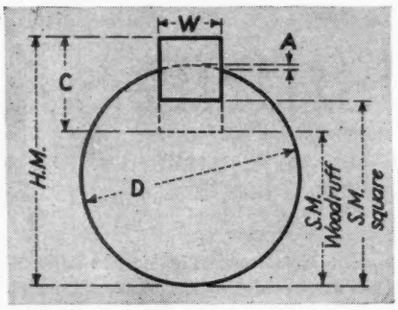
Wall thickness	Nominal diam. of shaft	Limits for ground shaft	Housing bore	Toler. limits	O.D. of bushing	Toler. limits	I.D. of bushing	Toler. limits	I.D. of bushing after burnishing	Toler. limits	Diam. of large end of burnisher
	1	+0.000 −0.001	1.375	+0.001 −0.000	1.378	+0.000 −0.001	1.002	+0.001 −0.000	1.002	+0.001 −0.000	1.004
3/16	1 1/4	+0.000 −0.001	1.625	+0.001 −0.000	1.628	+0.000 −0.001	1.252	+0.001 −0.000	1.252	+0.001 −0.000	1.254
	1 1/2	+0.000 −0.001	1.875	+0.001 −0.000	1.878	+0.000 −0.001	1.502	+0.001 −0.000	1.502	+0.001 −0.000	1.5045
	1 3/4	+0.000 −0.001	2.250	+0.001 −0.000	2.254	+0.000 −0.001	1.753	+0.002 −0.000	1.752	+0.002 −0.000	1.755
	2	+0.000 −0.001	2.500	+0.001 −0.000	2.504	+0.000 −0.001	2.003	+0.002 −0.000	2.003	+0.002 −0.000	2.007
1/4	2 1/4	+0.000 −0.001	2.750	+0.001 −0.000	2.754	+0.000 −0.001	2.254	+0.002 −0.000	2.253	+0.002 −0.000	2.257
	2 1/2	+0.000 −0.001	3.000	+0.001 −0.000	3.004	+0.000 −0.001	2.504	+0.002 −0.000	2.503	+0.002 −0.000	2.5075
	2 3/4	+0.000 −0.001	3.250	+0.001 −0.000	3.254	+0.000 −0.001	2.755	+0.002 −0.000	2.753	+0.002 −0.000	2.7575
	3	+0.000 −0.001	3.625	+0.001 −0.000	3.630	+0.000 −0.002	3.006	+0.002 −0.000	3.004	+0.002 −0.000	3.009
	3 1/4	+0.000 −0.001	3.875	+0.001 −0.000	3.880	+0.000 −0.002	3.256	+0.002 −0.000	3.254	+0.002 −0.000	3.259
5/16	3 1/2	+0.000 −0.001	4.125	+0.001 −0.000	4.130	+0.000 −0.002	3.507	+0.002 −0.000	3.504	+0.002 −0.000	3.5095
	3 3/4	+0.000 −0.001	4.375	+0.001 −0.000	4.380	+0.000 −0.002	3.758	+0.002 −0.000	3.754	+0.002 −0.000	3.7595
	4	+0.000 −0.002	4.625	+0.002 −0.000	4.631	+0.000 −0.002	4.008	+0.002 −0.000	4.004	+0.002 −0.000	4.011
	4 1/2	+0.000 −0.002	5.250	+0.002 −0.000	5.256	+0.000 −0.002	4.509	+0.003 −0.000	4.504	+0.003 −0.000	4.5115
	5	+0.000 −0.002	5.750	+0.002 −0.000	5.756	+0.000 −0.002	5.009	+0.003 −0.000	5.004	+0.003 −0.000	5.012
3/8	5 1/2	+0.000 −0.002	6.250	+0.002 −0.000	6.257	+0.000 −0.002	5.509	+0.003 −0.000	5.504	+0.003 −0.000	5.513
	6	+0.000 −0.002	6.750	+0.002 −0.000	6.757	+0.000 −0.002	6.010	+0.003 −0.000	6.005	+0.003 −0.000	6.014
	6 1/2	+0.000 −0.002	7.250	+0.002 −0.000	7.257	+0.000 −0.002	6.510	+0.003 −0.000	6.504	+0.003 −0.000	6.5145
7/16	7	+0.000 −0.002	7.875	+0.003 −0.000	7.884	+0.000 −0.003	7.010	+0.003 −0.000	7.005	+0.003 −0.000	7.015
1/2	8	+0.000 −0.002	9.000	+0.003 −0.000	9.009	+0.000 −0.003	8.011	+0.003 −0.000	8.006	+0.003 −0.000	8.017

All dimensions are given in inches

FACTORS FOR KEYWAY DIMENSIONS

A. C. RASMUSSEN
Chief Engineer, Insley Manufacturing Company

THE FACTORS given in this table make it possible to determine keyseat dimensions for square keys of width W and Woodruff keys of width W and depth C with fewer computations. Using the nomenclature given on the diagram, where D, W, and the ratio D/W are known, the ratio A/W is found in the table. From this the dimension A can be computed. In practice, the hub measurement, $H.M.$, should be made greater by about 0.005 in. and the shaft measurement, $S.M.$, should be held to about −0.002 in. tolerance.



All keys are set into the hub to a depth of $\frac{1}{2}W$ along the side of the key. For square keys,

$$H.M. = D + sW$$
$$S.M. = H.M. - W$$

For Woodruff keys,

$$H.M. = D + sW$$
$$S.M. = H.M. - C$$

D/W	A/W	s	D/W	A/W	s	D/W	A/W	s	D/W	A/W	s
3.00	0.086	0.414									
3.05	0.084	0.416	4.55	0.056	0.444	7.10	0.035	0.465	11.25	0.022	0.478
3.10	0.083	0.417	4.60	0.055	0.445	7.20	0.035	0.465	11.50	0.022	0.478
3.15	0.081	0.419	4.65	0.054	0.446	7.30	0.034	0.466	11.75	0.021	0.479
3.20	0.080	0.420	4.70	0.054	0.446	7.40	0.034	0.466	12.00	0.021	0.479
3.25	0.079	0.421	4.75	0.053	0.447	7.50	0.033	0.467			
3.30	0.078	0.422	4.80	0.053	0.447	7.60	0.033	0.467	12.25	0.020	0.480
3.35	0.076	0.424	4.85	0.052	0.448	7.70	0.033	0.467	12.50	0.020	0.480
3.40	0.075	0.425	4.90	0.052	0.448	7.80	0.032	0.468	12.75	0.020	0.480
3.45	0.074	0.426	4.95	0.051	0.449	7.90	0.032	0.468	13.00	0.019	0.481
3.50	0.073	0.427	5.00	0.051	0.449	8.00	0.031	0.469			
3.55	0.072	0.428	5.10	0.050	0.450	8.10	0.031	0.469	13.50	0.019	0.481
3.60	0.071	0.429	5.20	0.049	0.451	8.20	0.031	0.469	14.00	0.018	0.482
3.65	0.070	0.430	5.30	0.048	0.452	8.30	0.030	0.470	14.50	0.017	0.483
3.70	0.069	0.431	5.40	0.047	0.453	8.40	0.030	0.470	15.00	0.017	0.483
3.75	0.068	0.432	5.50	0.046	0.454	8.50	0.030	0.470	15.50	0.016	0.484
3.80	0.067	0.433	5.60	0.045	0.455	8.60	0.029	0.471	16.00	0.016	0.484
3.85	0.066	0.434	5.70	0.044	0.456	8.70	0.029	0.471	17.00	0.015	0.485
3.90	0.065	0.435	5.80	0.043	0.457	8.80	0.029	0.471	18.00	0.014	0.486
3.95	0.064	0.436	5.90	0.043	0.457	8.90	0.028	0.472	19.00	0.013	0.487
4.00	0.064	0.436	6.00	0.042	0.458	9.00	0.028	0.472	20.00	0.013	0.487
4.05	0.063	0.437	6.10	0.041	0.459	9.25	0.027	0.473	21.00	0.012	0.488
4.10	0.062	0.438	6.20	0.041	0.459	9.50	0.026	0.474	22.00	0.011	0.489
4.15	0.061	0.439	6.30	0.040	0.460	9.75	0.026	0.474	23.00	0.011	0.489
4.20	0.060	0.440	6.40	0.039	0.461	10.00	0.025	0.475	24.00	0.010	0.490
4.25	0.060	0.440	6.50	0.039	0.461				25.00	0.010	0.490
4.30	0.059	0.441	6.60	0.038	0.462	10.25	0.024	0.476			
4.35	0.058	0.442	6.70	0.038	0.462	10.50	0.024	0.476			
4.40	0.058	0.442	6.80	0.037	0.463	10.75	0.023	0.477			
4.45	0.057	0.443	6.90	0.036	0.464	11.00	0.023	0.477			
4.50	0.056	0.444	7.00	0.036	0.464						